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The 1993 RPA Timber Assessment Update

Richard W. Haynes, Darius M. Adams, and John R. Mills

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The 1993 RPA Timber Assessment Update

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CHAPTER 1. MANAGEMENT IMPLICATIONS

The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, as amended by the National Forest Management Act of 1976, directs the Secretary of Agriculture to prepare a Renewable Resource Assessment each decade and a Renewable Resource Program every 5 years. This Update reports changes in the timber resource situation first described in the 1989 RPA Timber Assessment (Haynes 1990).[1] More specifically, the purposes of this Update are two-fold.

1. *Analyze the timber resource situation to provide projections of the future cost and availability of timber products to meet the Nation's demands.* The Update focuses on prospective trends in demands for, and supplies of timber, and the factors that affect these trends, including changes in the land and timber resource base.

2. *Identify changing resource conditions that may warrant policy changes, or that may represent opportunities for private or public investment.* This Update interprets market and resource trends as a basis for determining how to manage and use the resource base to better meet private and public sector goals.

STUDY FINDINGS

The base projection represents an outlook in which the major economic determinants of timber demand and forest products supply evolve according to a specific set of assumptions (as described in chapter 2), but the policy environment—policies regulating both public and private forests and their management—is fixed. The base case provides an initial view of future prospects and a datum against which to measure the impacts of alternative assumptions on economic and policy developments. Because policies are assumed to be fixed, **the base case should not be interpreted as a "best guess" or "most probable" forecast.**

In broad terms, the base projection shows a future in which rising trends in the consumption of forest products are juxtaposed with a much more cyclical outlook for timber growth and inventories. Over the period 1990 to 2040, softwood harvests from U.S. forests rise by 35%, while hardwood harvest rises by more than 51%. Obtaining these increments in consumption requires annual sawtimber stumpage real price growth on the order of 1-2%. Softwood sawtimber markets are in a state of adjustment during the first two decades of the projection, rebalancing wood demands with a reduced stumpage supply. Inventory and harvest expansion on forest industry lands eventually force prices to stabilize and ultimately to decline. This is aided by reduced demand for softwood pulpwood in the South. At the same time, growing pulpwood demand for hardwoods produces a decline in hardwood inventories, lower hardwood lumber output, and rising hardwood sawtimber and pulpwood stumpage prices.

Earlier assessments (USDA Forest Service 1974, 1982) consistently projected a future with rising consumption, less rapid growth in timber inventories, and increasing real prices for stumpage and products. The present base analysis yields a similar view until about 2010, when declining growth in rates of consumption and increasing timber inventories about stabilize prices.

[1] *Analysis of the demand/supply situation for timber has a history dating back to 1876. This history is described in Appendix C of the 1989 RPA Timber Assessment. The structure, methodology, and much of the historical base developed in earlier assessments, and particularly those immediately preceding, have been carried forward with modifications and refinements.*

1. Over the next five decades, the consumption of paper and paperboard will grow more rapidly than any other category of forest products (about 1.2% per year). Consumption of roundwood in the manufacture of these products will rise at about 0.7% per year). Uncertainties in the outlook related to this sector, such as rates of wastepaper recycling and use, are particularly critical to the roundwood use projection.

2. Real prices of softwood sawtimber and softwood lumber rise steadily from current levels until 2010-2015, then stabilize or fall in subsequent periods. This reflects:

   a. In the near-term:

      (i) Reduction in public harvests in all regions, but particularly in the West.

      (ii) Limited ability of private timber owners in the West to sustain increased harvest because of limited merchantable inventories.

      (iii) Lumber demand recovers to near 1987 peak levels by 1995 and does not fall below that level for the remainder of the projection.

   b. In the long-term:

      (i) Maturation of young-growth forests on industrial timberlands in the Douglas-fir subregion and both industrial and nonindustrial lands in the South leads to increases in softwood cut.

      (ii) Growing utilization of recycled wastepaper in the production of paper and paperboard reduces growth in demand for softwood pulpwood, particularly in the South, allowing expanded harvest for solidwood products as pulpwood stands increase to sawtimber size.

3. The national impacts of public timber harvest reductions in the West will be lessened by significant interregional substitution, including increased lumber imports from Canada. Over the projection period,western regions will continue to lose market share (in all products) to eastern regions because of rising relative wood costs. This trend will accelerate if public harvest decreases further, if wastepaper recycling rates increase, or if major public tree planting programs are undertaken on nonindustrial lands.

4. Price increases in solidwood products and sawtimber until 2010 appear to be nearly inevitable, unless there is some major immediate reduction in timber demand, as might be possible with major shifts toward substitutes for solidwood products or higher levels of recycling. Pulp and paper prices, in contrast, exhibit either little or no price changes.

5. The South will be the major source of any expansion in softwood timber supply for the next 50 years. If high planting rates in the South continue into the 1990s, as assumed in the base case, product and timber prices will stabilize, and in some cases decline, after 2020.

6. Structural panel prices will be stable because of competition between plywood and oriented strandboard and waferboard, and nearly constant fiber costs for board products. Oriented strandboard and waferboard absorb essentially all of the growth for this class of product.

7. Rising real prices for hardwood lumber are caused by declining inventory trends which, in turn, result from land conversion to softwoods, limited intensity of hardwood silviculture, and large increases in demands for pulpwood.

8. Demands for softwood lumber and plywood are higher after 2000 than in the 1989 Assessment because of revised projections of consumption in the construction, residential upkeep and improvement, and shipping end-uses.

9. Softwood pulp product outputs grow less rapidly in this projection than the 1989 Assessment, while hardwood demand for pulp products grows much faster. Nonetheless, by 2040, pulpwood demand for softwoods rises to twice that for hardwoods in the base projection.

10. While there is considerable regional variation, total U.S. private softwood timber inventories will decline until 2000 on forest industry lands, then rise steadily through 2040; nonindustrial private inventories will rise steadily through the full projection period. Private hardwood inventories in 2040 are about 3% smaller than the 1991 levels on both industrial and nonindustrial ownerships.

11. Hardwoods will increase in importance relative to softwoods in total U.S. harvest as a result of increased use in lumber, fiber products, and fuelwood. In this expansion, the North has the potential to match the South in contributions to incremental fiber output. Hardwood area and inventory will drop, however, if past trends in softwood plantation establishment and limited hardwood management in the South continue.

12. Inventories on public forests will increase as harvest levels decrease in the early 1990s, and will remain at these reduced levels throughout the projection.

13. By 2040, U.S. forestland will comprise two distinct components: private inventories with relatively stable total volume, rapid growth, harvested close to minimum merchantable ages, and employing increasingly intensive silvicultural methods to grow softwoods; and public lands with rising inventories of older stands using much less intensive silviculture.

14. By 2040, the U.S. will remain a net forest products importer, but the gap between imports and exports on a volume basis will decline.

The alternative futures projections in chapter 4 augment these findings in several ways.

1. More intensive forest management and more planting do not limit short-term price increases or harvest shortfalls, although their long-term impacts can be substantial.

2. Demand for roundwood is quite sensitive to pulpwood price in the manufacture of paper and paperboard, but is fairly insensitive to sawtimber price in the production of lumber. Restrictions on roundwood supply that act to raise prices of pulpwood cause paper and board producers to shift rapidly to alternative fiber sources (including waste paper). This lessens, or potentially even reverses, the impact of the restriction on sawtimber users as unharvested pulpwood grows to sawtimber sizes. Increments in supply have the opposite effects.

3. Restrictions on Canadian timber harvest could have major impacts on U.S. markets for products and stumpage, raising prices, domestic output and lowering consumption.

CHAPTER 2. MAJOR DEMAND AND SUPPLY ASSUMPTIONS

Projections are consequences of assumptions used in the projection process. This chapter provides a summary of the changes in key assumptions since the 1989 Assessment, especially those that are important determinants of the supply and the demand for various forest products. These assumptions are required as inputs to the model of the forest sector[2] used to develop projections for this Assessment. This model (the Timber Assessment Market Model—TAMM[3]) was originally developed for the 1979 RPA Assessment. It is based on systems analysis and quantitative techniques, and has been extensively revised for this Update.[4]

BASIC ASSUMPTIONS

In the future, trends in the demand for forest products will continue to be largely determined by growth in U.S. population, income, and economic activity. Projections of future levels for these key demand determinants, many of which were derived from "U.S. Long-Term Economic Outlook" (Wharton Econometric Forecasting Associates 1991), are summarized in table 1. For the most part, these projections are little changed from the 1989 Assessment, except for revisions in the population series to reflect the 1990 Census and associated population projections.

Economic Activity and Demographics

The projections in table 1 indicate:

1. U.S. population growth that slows because of reduced fertility rates but does not achieve a zero rate during the projection period, because of net immigration.
2. Growth in aggregate economic activity (as measured by the gross national product [GNP]) is expected to range between 2% and 3% over the next 50 years, in contrast to the average of 3-4% characteristic of the 1960-1990 period. Paralleling expansion in GNP, total disposable personal income increases more than three times (table 1) and some 2.5 times on a per capita basis. Although anticipated economic growth is slower than in the past, this projection still portrays a strong and resilient future economy, with a larger and increasingly affluent population.

Energy Costs

The long-term outlook for energy costs has moderated in the past 5 years. The 1989 Assessment assumed that there would be a resumption of growth in energy prices despite sharp price drops in the 1980s. Recent projections by the Department of Energy provide a rough view of trends through 2040.[5] These projections show world crude oil prices (prices are in 1982 dollars, net of inflation or deflation) increasing from $13.35 in 1990 to $37.85 per barrel in 2040. These projections are substantially lower than those used in the 1989 Assessment and result from increased substitution of methanol produced from natural gas and liquid fuels produced from other sources.

TIMBER DEMAND ASSUMPTIONS

Projections of demand for lumber, structural panels, and nonstructural panels were based on the end-use approach used in previous Assessments. In this approach, future consumption of a particular product (such as lumber) in a specific end-use market (such as housing) is estimated by multiplying the projected consumption per unit of activity in the end-use market (termed end-use factors) times the projected level of end-use activity. This requires assumptions about the levels of activity in each end-use category and the consumption of various forest products per unit of end-use activity (the end-use factors).

[2]*A forest sector model, in general, combines activities related to the use of wood: forest growth and harvest; the manufacture of pulp, paper, and solid wood products; and international trade and intermediate and final consumption of these products (Kallio et al. 1987).*

[3]*The original model is described in Adams and Haynes (1980) and Haynes and Adams (1985).*

[4]*Some of these revisions include a new model for the hardwood section; the division of the Rockies into two regions—the Northern Rockies and the Southern Rockies; a complete model of the National Forest sales process including bid prices and uncut volume under contract; and reestimation of all of the various relationships in TAMM with updated data sets.*

[5]*Personal Communication. 1992. Ken Skog, FPL, Madison, WI.*

Table 1.—Population, gross national product, and disposable personal income in the United States, selected years, 1929-1990, with projections to 2040.

Year	Population		Gross national product		Disposable personal income		Per capita disposable personal income	
	Millions	Annual rate of change	Billion 1982 dollars	Annual rate of change	Billion 1982 dollars	Annual rate of change	1982 dollars	Annual rate of change
1929	121.8	—	709.6	—	498.6	—	4,091	—
1933	125.7	0.8	498.5	-8.4	370.8	-7.3	2,950	-7.8
1940	132.1	0.8	772.9	7.9	530.7	6.2	4,017	5.4
1945	139.9	1.1	1,354.8	-1.9	739.5	-1.3	5,285	-2.4
1950	151.7	1.7	1,203.7	8.5	791.8	7.1	5,220	6.2
1955	165.3	1.8	1,494.9	5.6	944.5	5.6	5,714	3.8
1960	180.8	2.1	1,665.3	2.2	1,091.1	2.2	6,036	0.1
1965	194.3	1.3	2,087.6	5.8	1,365.7	5.8	7,027	4.5
1970	205.1	1.2	2,416.2	-0.3	1,668.1	4.3	8,134	3.1
1975	216.0	1.0	2,865.0	-1.3	1,931.7	1.9	8,944	0.9
1976	218.0	0.9	2,826.7	5.3	2,001.0	3.6	9,175	2.6
1977	220.3	1.0	2,958.6	4.7	2,066.6	3.3	9,381	2.2
1978	222.6	1.1	3,115.2	5.3	2,167.1	4.9	9,735	3.8
1979	225.1	1.1	3,192.4	2.5	2,202.6	2.1	9,829	1.0
1980	227.7	1.2	3,187.1	-0.2	2,214.3	0.1	9,723	1.1
1981	230.1	1.0	3,248.8	1.9	2,248.6	1.5	9,773	0.5
1982	232.4	1.0	3,166.0	-2.5	2,261.5	0.6	9,732	-0.4
1983	234.8	1.0	3,279.1	3.6	2,331.9	3.1	9,930	2.0
1984	237.1	0.9	3,501.4	6.8	2,469.8	5.9	10,419	4.9
1985	239.3	1.0	3,607.5	3.0	2,542.2	2.9	10,622	1.9
1986	241.6	1.0	3,713.3	2.9	2,645.1	4.0	10,947	3.1
1987	243.9	1.0	3,863.5	4.0	2,691.2	1.7	11,034	0.8
1988	246.3	1.0	4,015.5	3.9	2,785.1	3.5	11,308	2.5
1989	248.8	1.0	4,116.1	2.5	2,839.9	2.0	11,414	0.9
1990	251.5	1.1	4,157.0	1.0	2,894.7	1.9	11,510	0.8
1991	252.7	0.5	4,121.5	0.1	2,983.8	3.1	11,808	2.6
1992	255.5	1.1	4,222.5	2.4	3,071.3	2.9	12,021	1.8
				Projections				
2000	272.0	0.8	5,383	2.6	3,580.7	2.1	13,164	1.4
2010	291.0	0.7	7,031	2.7	4,503.0	2.3	15,474	1.6
2020	307.0	0.5	9,166	2.7	5,697.7	2.4	18,559	1.8
2030	318.0	0.4	11,957	2.7	7,259.5	2.5	22,829	2.1
2040	327.0	0.3	15,627	2.7	9,313.3	2.5	28,481	2.2

Sources: Historical Data—Council of Economic Advisors 1992. Projections—The WEFA Group Special Report to the Forest Service 1987, WEFA 1991.

Determinants of End-Use Activity

Projections of end-use activity are derived from the population, economic activity, income, and energy cost assumptions. Key end-use activity concepts include the number of housing starts and house size, levels of expenditures on residential upkeep and improvement, levels of expenditures for nonresidential construction, the index of manufacturing production, and measures of activity in shipping and transportation. Projection methodologies vary but generally involve estimated relationships (based on historical data) between the selected determinant and various population or macroeconomic variables.

Housing

Few revisions were made in the projections of housing starts. Residential construction continues to be the dominant market for most timber products. Given levels of the key factors that determine demand for new housing units (household formations,

Table 2.—Projections of number (in millions) of households, housing starts, and replacement assumptions.

Year	Number of households	Total starts	Single family	Multiple	Mobile
1960	52.8	1.400	1.009	0.287	0.104
1970	63.4	1.870	0.815	0.654	0.401
1980	80.8	1.535	0.852	0.461	0.222
1981	82.4	1.341	0.705	0.395	0.241
1982	83.5	1.312	0.663	0.409	0.240
1983	83.9	2.009	1.068	0.645	0.296
1984	85.4	2.051	1.084	0.672	0.295
1985	86.8	2.026	1.072	0.670	0.284
1986	88.5	2.049	1.179	0.626	0.244
1987	89.5	1.853	1.146	0.474	0.233
1988	91.1	1.706	1.081	0.407	0.218
1989	92.8	1.574	1.003	0.373	0.198
1990	93.3	1.381	0.895	0.298	0.188
1991	94.3	1.184	0.840	0.173	0.171
1992	95.7	1.410	1.030	0.170	0.210
2000	108.0	1.690	1.056	0.328	0.306
2010	124.0	1.684	1.007	0.379	0.298
2020	139.0	1.849	1.139	0.410	0.300
2030	151.0	1.692	1.024	0.368	0.300
2040	161.0	1.552	0.921	0.331	0.300

replacement of units lost from the housing stock, and maintenance of an inventory of vacant units) levels of demand continued high in the late 1980s, resulting in an average of nearly 2.0 million units for the second half of the decade. Housing demand fell in the early 1990s to about 1.4 million annual starts, and is expected to remain at that level in the second half of the decade. Starts are subsequently projected to increase to about 1.7 million annually by 2010, then decline to 1.5 million by 2040 (table 2). After 2010, a larger fraction of new housing starts are for houses that replace older existing houses.

In addition to the numbers of new units demanded, their size is also an important determinant of the amount of timber products used in housing. The average size of single-family housing units, though showing some fluctuation, has grown fairly steadily over the past 40 years, rising from nearly 1,150 square feet in the early 1950s to about 2,080 square feet in 1990. This increase in floor area has more than offset a declining trend in wood use per square foot of floor area, resulting in increased average lumber use per single-family unit. Unit size in multifamily structures also has increased; however, the rise has been somewhat smaller and more erratic than in single family structures. For example, the size of average new multifamily units in 1990 was about 1,000 square feet, 26% above the average in the early 1950s, but at about the same level as the mid-1970s. Average floor area in new mobile homes, which more than doubled between 1950 and the mid-1970s, has continued to rise because of the increasing share of double-wide and expandable units.

In the 1989 Assessment, single family house size was expected to rise slowly to 2,010 square feet by 2040. This level was exceeded by 1990, however, necessitating a major revision in the house size projections in the Update. Future house size will reflect upward pressures from rising incomes and wealth and consumer preferences for more space, while rising land costs and decreasing household size (with an aging and less fecund population) will act to slow the rate of growth. We now expect that house size will change little during the remainder of the 1990s, then increase after 2000 to about 2,275 square feet by 2040. This increase will lead to growth of 13% in lumber consumption per unit by 2040.

Residential Upkeep and Repair

In addition to the timber products consumed in the production of new housing units, substantial and growing volumes—about 20% of lumber and structural panel products and 15% of nonstructural panel products—are used each year for the upkeep and improvement of existing units. Expenditures for residential upkeep and repair in the last several years averaged nearly $900 (1982 dollars) per household. This is almost three times the level observed in the early 1970s and a third higher than assumed in the 1989 Assessment.

Update projections of expenditures for residential upkeep and repair are shown in table 3. These projections assume a fixed level of expenditures per household (expressed in 1982 dollars) derived from the data for the 1980s. Assuming a stable vacancy rate, this projection is equivalent to a constant upkeep and repair expenditure per housing unit.

New Nonresidential Construction

In recent years, about 10% of lumber, plywood, and other structural and nonstructural panel products has been used in the construction of offices, stores, churches, and a wide variety of other nonresidential buildings, and in other types of construction,

Table 3.—Projections of major determinants of solid wood products demand.

Year	Residental repair and remodeling expenditures	Value of nonresidental construction	Index of manufacturing	Pallets
	Billion 1982 dollars		*1977=100*	*Millions*
1960	—	125.0	48.0	62
1970	42.1	172.2	77.0	126
1980	52.1	165.9	108.2	258
1981	47.7	164.1	110.5	252
1982	45.3	160.3	102.2	228
1983	48.0	150.4	110.2	258
1984	65.6	162.8	123.4	261
1985	74.0	177.4	126.4	275
1986	82.0	175.4	129.1	295
1987	82.7	176.3	134.7	314
1988	89.2	209.4	142.7	340
1989	69.9	212.8	148.2	354
1990	72.0	217.6	96.3	359
1991	65.6	204.1	94.2	362
1992	68.7	205.8	93.7	NA
2000	96.5	223.1	193.0	550
2010	110.7	245.3	252.1	630
2020	124.2	270.4	328.6	675
2030	134.7	297.7	428.7	695
2040	144.0	328.4	560.3	700

such as roads, dams, and water and sewer systems. Although expenditures for the various classes of construction have fluctuated widely in response to changing economic conditions, the long-run trend for all types combined has been upward.

Projections based on the close historical relationship between changes in gross national product and changes in expenditures for nonresidential building and nonbuilding construction indicate additional expenditures (table 3) but at a declining rate of growth over the next five decades, except for farm nonresidential buildings (which has been falling for the past four decades).

Manufacturing

Since the mid-1970s, about 10% of the lumber, 5% of the structural panel products, and nearly 25% of the nonstructural panel products have been used to manufacture a wide range of products, such as household furniture, sports equipment, games and toys, and commercial and industrial equipment. Of these products, furniture manufacturing is the largest user of sawtimber. As in the case of nonresidential construction, the projected rates of increase in the value of shipments for all groups of products, including household furniture, drop significantly over the projection period.

Shipping

In recent years, nearly 18% of all lumber and about 3% of the structural and nonstructural panel products consumed have been used in the production of wooden pallets, containers, and for dunnage, blocking, and bracing of goods for shipping. Pallets account for about three-fourths of the lumber and nearly two-thirds of the panel products consumed in shipping.

During the past three decades, pallet production rose rapidly with the introduction of new methods of materials handling, the construction of facilities geared to the use of pallets, and increases in the volumes of manufactured and agricultural goods shipped. The rate of increase in the post-1982 recession period has been especially rapid. Projections of pallet output (table 3) are based on the relationship of pallet use to the value of manufacturing shipments and the assumed growth in shipments as the gross national product rises. They are about 10% higher than projections in the 1989 Assessment. As in the past, the rate of growth in pallet demand is expected to drop rapidly over time. This reflects competition from alternate systems and materials, and means that growth in pallet demand for use in new materials-handling systems gradually ends.

Trends in End-Use Factors

Projected demand also depends on changes in product **end-use factors**—the volume of timber products used per square foot of housing unit floor area, per dollar of construction expenditure, per pallet, or other unit of measure of end-use market activity. Derivation of assumptions regarding the trends in end-use factors varies by category of product.

For nonstructural products, projections of end-use factors for the major markets have been based on current trends, modified to be consistent with expected future movements of relative prices and associated changes in the various non-price factors. In general, this procedure has resulted in a continua-

tion of recent trends in the various end-use factors. For example, additional decreases in the factor for particleboard use in housing and other light building construction are projected because of the likely penetration of oriented strandboard and waferboard products in these uses caused by price and environmental factors. After 2000, the projected rates of increase or decrease for the various product end-use factors were reduced, recognizing that continued change becomes more difficult as markets are saturated or as market share approaches zero. This phenomenon of declining rates of substitution as limits of market share (0 or 1) are approached may reflect sharply declining importance of the product in total cost or other factors. An example in the forest products sector is the case of insulation board used in residential construction, where there has been extensive displacement by other products, but reduction in market share has slowed sharply short of zero.

For lumber and structural panels, projected use factors were based on two calculations. First, upper and lower limits for each factor were calculated. The upper limit estimates the potential maximum level that a product's end-use factor might reach if its substitutes are consistently more costly to use. Similarly, the lower limit is the minimum potential level to which its use factors might fall if the product is consistently more costly than its substitutes. This latter level need not be zero. Non-zero lower limits imply some characteristics of an end-use where there are no technically or economically feasible substitutes foreseen over the projection. These limits define the range of possible use factor variation over time.

Second, the projected paths of the end-use factors within these limits were based on the relative in-place costs of key competing products or systems. In-place cost projections are based on calculations involving the amount of inputs used in competing production systems and the prices of these inputs. For example, in one aspect of residential construction, we compare the relative costs of a concrete block versus treated wood foundations. These two systems use different amounts of labor, wood, and concrete, and they compete as alternative methods of foundation construction in single family homes.

The change in wood end-use factors over time depends on which system's position is favored by the in-place cost comparison. If the system that uses more wood is less expensive, then the end-use factor for wood in that application rises. When the wood-intensive system is more expensive, then wood's end-use factor falls. The amount of change is partly determined by functional relationships derived from numerical analysis of past end-use factor trends (Spelter 1984, 1985), and varies with the product and proximity of the end-use factor to its limits. Finally, these estimated relationships along with assumptions regarding costs of non-wood inputs and end-use activities are used to make the projections of demand contained in this Update.

Demand for Pulpwood

The demand for pulpwood is derived from the demand for paper and board, modified in the near term by increases in the use of recycled fiber. Revisions to paper and board demand estimates for the 1993 Update indicate a somewhat slower growth in paper and board consumption than projected in the 1989 Assessment. In the base case, paper and board consumption in the United States is projected to reach nearly 100 million tons by the year 2000, and nearly 150 million tons by the year 2040. Although these projections indicate slower growth than paper and board consumption than in the 1989 Assessment, the base projections still indicate increasing aggregate demand for fiber products (paper and board). In the base projection, the United States would maintain per capita consumption levels (currently about 700 pounds per capita) for paper and board that are much higher than in other industrial countries (Ince 1994). Fundamental determinants of demand for paper and board are gross domestic product (GDP) and population, with downward adjustments in relationships of demand to GDP reflecting some anticipated substitution of paper and board products by electronic media, plastics, etc. Demand for pulpwood is determined by regional production capacities and production volumes by process for paper and board commodities. Production capacities by process are projected to change over time, in response to demand growth and market conditions, with growth by process determined by relative profitability and costs of each process. Processes encompass recycled and virgin fiber technologies.

An important change in the Update was linkage of the model of the pulp and paper sector (the North

American Pulp and Paper or NAPAP Model)[6] and TAMM/ATLAS in an iterative solution process to arrive at a set of fiber requirements that balance prices, timber removals and timber inventories in both models. This solution method approximates how the solid wood and fiber sectors interact through the market for pulpwood.

Assumptions regarding future trends in recycling also have been substantially revised from the 1989 Assessment. These are described in detail in the report by Ince (1994). Projections of the increased use of wastepaper as raw material for domestic production of paper and paperboard were modified to reflect recent and ongoing changes. In the 1989 Assessment, wastepaper use was assumed to rise slowly from 21% of fiber used in the manufacture of paper and board in 1986 to 33% by 2040. In the Update, wastepaper used is expected to reach approximately 40% of fiber used in the manufacture of paper and board by the early part of the next century, rising to 45% by the year 2040.

Fiber demands under these higher levels of wastepaper use are shown in table 4. In general, wood use drops by 15% by 2040 from the 1989 Assessment because of the higher levels of wastepaper use included in the Update (fig. 1). This decrease is almost entirely in softwood fiber, as technical innovations lead to increases in the use of hardwoods.

Wood Fuel

Efficiency of home wood burning increased substantially between 1970 and 1986 with expanded use of airtight stoves and fireplace inserts. Efficiency has increased further since 1986 with new national wood

[6]*The NAPAP model is a recent modeling development designed to project the evolution of markets and technology of the pulp and paper sector in the United States and Canada. The model incorporates advancements in economics modeling of trade and environmental impacts within the pulp and paper sector. It is a regional market model, with five supply and production regions (Canada East and West; U.S. North, South, and West), U.S. and Canada demand regions, and additional trading regions representing Pacific, Atlantic, and Latin American markets. Regional markets and trade are modeled for all categories of paper, paperboard, and market pulp, and all categories of pulpwood and recycled paper. The model combines information on supply and demand, manufacturing technology, and transportation costs to compute regional market equilibria year to year, using a price-endogenous linear programming system. The model allocates annual growth in production capacity to processes and regions as a function of profitability and market conditions. See Ince (1994) for details of model construction and application.*

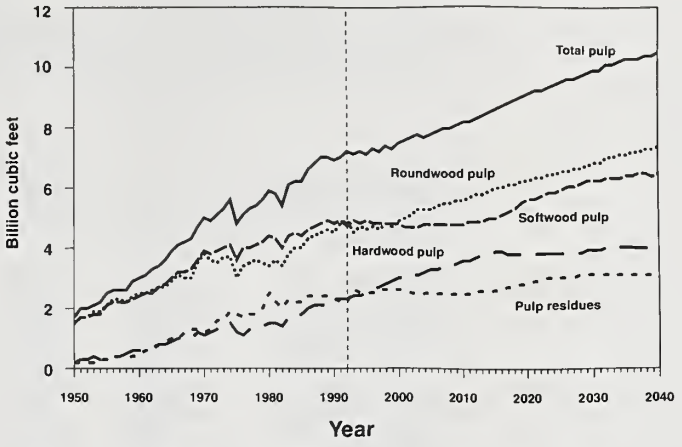

Figure 1.—U.S. pulpwood supply quantities by category.

stove performance standards set by the U.S. Environmental Protection Agency. With a greater proportion of certified stoves relative to non-certified stoves and fireplaces, the overall efficiency (percent of BTUs converted to useful heat) of wood stoves, furnaces and fireplaces is projected to increase from 42% in 1986 to 56% in 2010 and 67% in 2040. Wood burning efficiency is assumed to increase relative to efficiency of non-wood burning system — quite rapidly in the near future, then more slowly in later decades. Efficiency of industrial wood burning is assumed to improve at the same rate as for non-wood systems. The rate of increase is projected to be 1.3% per year between 1986 and 2010, and 0.5% per year between 2010 and 2030.

Fuelwood

Total fuelwood consumption derived from roundwood in 1986 was an estimated 3.10 billion cubic feet. Of this total, 26% or 0.8 billion cubic feet came from growing stock. The remainder came from non-merchantable portions of growing stock trees, non-growing stock trees on timberland, from trees on other (less productive) forest land, and from urban areas. About 74% of the growing stock volume was from hardwoods. The sharp decrease in deflated world oil prices after 1985 (41% between 1985 and 1989) led to reductions in residential fuelwood use and slower growth in industrial fuelwood use.

Wood energy sources include wood directly from trees on a wide range of land types, from mill residue, from discarded products and construction demolition waste, and from pulp mill black liquor. The

Table 4.—Pulpwood consumption (in million cubic feet) by the woodpulp industry in the United States, by species group, roundwood and residue, and region, 1990, with projections to 2040.

Region and species group	1990[1]	Projections				
		2000	2010	2020	2030	2040
Northeast	728	866	925	999	1,068	1,159
Softwood	380	434	453	493	519	555
Roundwood	317	358	366	404	435	472
Residue	63	76	87	89	84	83
Hardwood	348	432	472	506	549	605
Roundwood	300	393	440	481	530	592
Residue	48	39	32	25	19	13
North Central[2]	589	689	719	750	784	831
Softwood	160	164	152	148	138	131
Roundwood	140	143	133	132	127	123
Residue	21	21	19	16	11	8
Hardwood	428	525	567	602	645	700
Roundwood	349	444	482	511	546	590
Residue	79	81	85	92	100	110
Southeast	2,164	2,559	2,494	2,542	2,586	2,658
Softwood	1,588	1,788	1,673	1,796	1,995	2,183
Roundwood	1,088	1,208	1,108	1,266	1,491	1,769
Residue	500	579	566	530	505	414
Hardwood	576	771	821	746	591	475
Roundwood	398	581	641	586	461	376
Residue	178	190	180	160	129	99
South Central	2,480	3,319	3,671	4,094	4,467	4,903
Softwood	1,581	1,947	2,004	2,342	2,817	3,280
Roundwood	1,086	1,278	1,241	1,502	1,875	2,359
Residue	495	669	763	839	942	921
Hardwood	899	1,373	1,667	1,753	1,650	1,623
Roundwood	668	1,116	1,382	1,442	1,329	1,277
Residue	231	257	285	311	321	346
Rocky Mountains[3]	191	134	133	150	170	193
Softwood	177	117	112	124	140	159
Roundwood	49	45	53	66	81	98
Residue	128	73	59	58	59	60
Pacific Southwest[4]	156	111	110	126	145	169
Softwood	145	98	95	109	126	149
Roundwood	24	22	29	63	64	56
Residue	121	76	66	46	63	92
Hardwood	11	13	15	17	19	20
Roundwood	5	6	7	8	10	12
Residue	6	7	8	9	9	9
Pacific Northwest-West	820	536	482	503	527	563
Softwood	763	477	420	438	465	503
Roundwood	184	131	115	111	106	100
Residue	579	347	305	327	360	403
Hardwood	57	59	61	64	62	60
Roundwood	33	33	34	34	34	31
Residue	24	26	27	30	29	29
Pacific Northwest-East	56	39	37	43	49	58
Softwood	56	39	37	43	50	58
Roundwood	13	10	10	10	11	12
Residue	43	29	28	32	38	46

(continued)

Table 4.—(continued).

Region and species group	1990[1]	Projections 2000	2010	2020	2030	2040
United States[5]	7,184	8,252	8,571	9,208	9,797	10,535
Softwood	4,851	5,064	4,947	5,493	6,250	7,017
Roundwood	2,902	3,195	3,054	3,556	4,188	4,990
Residue	1,950	1,869	1,893	1,937	2,062	2,028
Hardwood	2,319	3,172	3,603	3,689	3,516	3,483
Roundwood	1,753	2,572	2,986	3,063	2,910	2,877
Residue	566	600	616	627	607	606

Note: Data may not add to totals because of rounding.

[1]*Data for 1991 is not summarized.*

[2]*Includes North Dakota, South Dakota, Nebraska, and Kansas.*

[3]*Excludes North Dakota, South Dakota, Nebraska, and Kansas.*

[4]*Excludes Hawaii.*

[5]*Total includes small amounts of hardwood in Rocky Mountains and Pacific Northwest-East.*

model used to project wood energy consumption considers all these sources, because for some end uses they are partially interchangeable. The projections given in table 5, however, include only wood from trees (from all land sources), with one exception. Logging residue used for fuel, while explicitly considered in this model, is not included in table 5, because it is accounted for elsewhere in this report.

Fuelwood Demand Projections

The National Wood Energy Model (NAWEM) projects wood energy use for three regions - North, South, and West.[7] This use is further subdivided among subregions based on continuation of historical trends in the shares of fuelwood use. As a result of projected cost increases for fossil fuels relative to wood fuels in all regions, and increases in residential and industrial/commercial/utility total energy needs, fuelwood use from roundwood (excluding logging residue) is projected to increase from 3.1 billion cubic feet in 1986 to 4.8 billion cubic feet in 2040. Some three-fifths of this 55% increase occurs in the first 25 years of the 54-year projection period (1986 to 2040). The amount of fuelwood from growing stock volume is projected to increase from 0.8 billion cubic feet in 1986 to 1.1 billion cubic feet in 2040. This is a smaller increase, compared to total fuelwood use, and results from a decline in the proportion of fuelwood from growing stock volume from 26% in 1986 to 22% in 2040. The growing stock proportion declines for two reasons. First, residential use currently accounts for most roundwood use, and growing stock makes up 20-25% of the total. As residential use increases, it is projected that nongrowing stock sources will be less expensive and, therefore, increasingly favored over growing stock. Second, as industrial/commercial/utility use increases, it will use more roundwood relative to mill residue. Most of this roundwood will be in the form of whole tree chips. Chipping operations will increasingly take both fuel chips and pulp chips from stands, with fuel chips coming largely from non-growing stock.

Industrial/commercial/utility fuelwood use is projected to grow more rapidly than residential use — 105% growth versus 30% growth between 1986 and 2020 — as mill residue supplies are fully used for fuel, and roundwood is used more heavily. Between 2020 and 2030, residential and industrial/commercial/utility fuelwood use increase at slower rates, 34% and 16%, respectively.

Softwood use increased from 17% of fuelwood in 1986 to 19% in 1992 and is expected to remain at that

[7]*Skog, Kenneth E. 1993. Projected wood energy impact on U.S. Forest Wood Resources. In: Proceedings of the First Biomass Conference of the Americas, August 30- September 2, 1993, Burlinton, VT. USDOE National Renewable Energy Laboratory, Golden, CO. p 18-32.*

Table 5.--Fuelwood consumed (in billion cubic feet) in the United States by species group, and growing stock/non growing stock source, in 1986 with projections to 2040.

Year	Roundwood			Growing stock		
	Total	Hard-wood	Soft wood	Total	Hard-wood	Soft-wood
			Northeast			
1986	0.98	0.89	0.08	0.13	0.12	0.01
2000	1.19	1.04	0.16	0.18	0.14	0.04
2010	1.34	1.12	0.22	0.20	0.15	0.05
2020	1.39	1.19	0.20	0.20	0.16	0.05
2030	1.47	1.30	0.17	0.20	0.16	0.04
2040	1.59	1.45	0.14	0.21	0.18	0.03
			North Central			
1986	0.85	0.81	0.04	0.11	0.11	0.01
2000	1.00	0.92	0.08	0.15	0.13	0.02
2010	1.10	0.98	0.12	0.16	0.13	0.03
2020	1.14	1.02	0.12	0.17	0.14	0.03
2030	1.21	1.10	0.10	0.16	0.14	0.02
2040	1.31	1.21	0.09	0.17	0.15	0.02
			South			
1986	0.74	0.68	0.06	0.33	0.29	0.04
2000	0.80	0.74	0.06	0.37	0.32	0.04
2010	0.86	0.75	0.12	0.40	0.32	0.07
2020	0.88	0.77	0.10	0.38	0.32	0.06
2030	0.91	0.85	0.07	0.36	0.31	0.05
2040	1.00	0.93	0.07	0.35	0.30	0.06
			Rocky Mountains			
1986	0.10	0.03	0.08	0.01	0.00	0.01
2000	0.11	0.03	0.08	0.01	0.00	0.01
2010	0.12	0.03	0.09	0.01	0.00	0.01
2020	0.14	0.04	0.10	0.01	0.00	0.01
2030	0.15	0.05	0.10	0.01	0.00	0.01
2040	0.17	0.05	0.12	0.02	0.00	0.01
			Pacific Coast			
1986	0.43	0.17	0.26	0.22	0.08	0.14
2000	0.46	0.17	0.29	0.26	0.09	0.17
2010	0.52	0.19	0.32	0.29	0.11	0.18
2020	0.57	0.21	0.36	0.30	0.11	0.19
2030	0.65	0.25	0.40	0.30	0.11	0.19
2040	0.74	0.25	0.49	0.30	0.12	0.18
			United States			
1986	3.10	2.58	0.52	0.80	0.60	0.20
2000	3.56	2.90	0.67	0.96	0.69	0.28
2010	3.95	3.07	0.88	1.06	0.71	0.35
2020	4.11	3.24	0.88	1.07	0.73	0.34
2030	4.39	3.55	0.84	1.03	0.72	0.30
2040	4.81	3.90	0.91	1.05	0.75	0.30

level. The proportion of softwood roundwood use in 1986 varied from 73% and 64% for the Rocky Mountains and Pacific Coast Regions to less than 10% in other regions. The Northeast, North Central, and South have the largest total fuelwood use at present; this predominance is projected to continue through 2040. The most rapid growth in demand is projected for the Pacific Coast, Rocky Mountains, and Northeast with increases of 73%, 64%, and 63%, respectively, between 1986 and 2040.

Trade Projections

Most solid wood trade flow projections are developed by analysis outside of TAMM/ATLAS. The single exception is the importation of softwood lumber from Canada that is explicitly considered in the model. These projections include:

- Softwood lumber: exports; imports from countries other than Canada.
- Hardwood lumber: exports; imports.
- Structural Panels: plywood imports, exports; oriented strandboard/waferboard imports, exports.
- Non-structural Panels: hardwood plywood imports, exports; insulating board imports, exports; hardboard imports, exports; particleboard imports, exports.
- Logs: softwood imports, exports; hardwood imports, exports.

Specific assumptions are shown in chapter 3 in tables for specific products. Methodologies used for these projections vary from product to product, but most rest on the experience and judgment of Update analysts and reflect continuation of current trends.

TIMBER SUPPLY ASSUMPTIONS

The supply of timber at any point in time is modeled, in part, as a function of private timber inventory levels, stumpage prices, and the amount of public harvest available. Projections require models of forest growth, and assumptions on private timberland management, timberland area change and forest type transition, the efficiency of harvest utilization, harvest flows from public timberlands, and an array of market forces.

Several modeling changes have taken place since the 1989 Assessment. First, new timber inventories for the entire South required an update and review of parameters for growth and yield relations in the South. Second, the Rocky Mountain region was split into northern and southern subregions, and all growth and yield parameters were updated. New inventories were available for the two states in the northern subregion (Idaho and Montana). Third, the Douglas-fir subregion in the Pacific Northwest was updated with a new inventory from western Washington.

Inventory Projection System

The Aggregate Timberland Assessment System (ATLAS; Mills and Kincaid 1992) was used to project inventories on the approximately 343 million acres of privately owned timberland. This system is a time-based, deterministic framework that allows for customization of inputs to reflect regional and subregional timber growth and yield attributes. The timber inventory data were derived from 79,000 plot summary records provided by various USDA Forest Service Forest Inventory and Analysis (FIA) Units. These inventories were aggregated into strata defined by 9 regions, 2 ownerships, up to 10 forest types, and 18 age classes. Three site classes and five management types were developed for the South and in the Pacific Northwest Douglas-fir regions. In other regions, only one site group and one management intensity type were used. Age class intervals were set at 5 years in the South and 10 years elsewhere.

Projection periods for these strata are consistent with inventory age classes. The projection mechanism computes growth using density standards (yield tables) and density change parameters. Each cell in the starting inventory has an independent yield function. Growth is the result of an interaction between the current stocking density, the yield standard, and the density change function. Projected cells reflect net cubic feet of inventory growing stock. Private harvests are generated through an interaction between ATLAS and TAMM that results in an equilibrium solution between supply and demand in both product and stumpage markets.

In principle, ATLAS is not strictly an even-aged model. When inputs are aggregated at the regional level, age classes function, in effect, like growth classes. Growth and harvest take place across this range of classes. The ATLAS harvest mechanism can account for both partial harvests and commercial thinning. Final harvest also can be proportioned across a range of age classes: the treated acres may be regenerated in alternative management levels, assumed to change timber type, or withdrawn from the timberland base.

The area change and type transition inputs for this Update were derived from other models (see the 1989 Assessment). Yield tables and density change parameters were either computed from the FIA plot data, derived from previous studies, generated from other models, or acquired from published sources.[8]

Timber Management Assumptions

A major attribute of the ATLAS model is that it can simulate the shifting of acres into management intensities and compute resulting changes in yields based upon alternative assumptions about future land management activities. This mechanism was implemented for the two Southern regions and the Pacific Northwest Douglas-fir subregion. In each case, five alternative management intensities were developed.

In the South, it was assumed that intensive site preparation and management would occur on pine plantations in the industry and corporate ownerships. New inventories were fitted to the yields and growth coefficients developed for the 1989 Assessment. The management alternatives were: (1) regular planted stock without thinning, (2) regular planting stock with thinning, (3) genetically improved planting stock without thinning, (4) genetically improved planting stock with thinning, and (5) genetically improved planting stock without thinning but with the most intensive site-preparation and management practices. Past 1995, it was assumed that all new pine plantations would be planted with genetically improved stock. By 1995, it was also assumed that 50% of all new pine plantations established on industry land were enrolled in management intensity 5. Slightly lower levels were assumed on other corporate lands, and on the farmer and other private ownership only 5% of the plantation acres were

[8] *The inventory data inputs and assumptions are summarized in Inventory, growth and management assumptions for the 1993 RPA timber assessment, Mills 1993.*

enrolled in management intensity 5. Stands of natural pine also included a management intensity for commercial thinning, but no shifts in management occur in the projection.

In the Pacific Northwest Douglas-fir subregion, five management intensities were developed for the Douglas-fir, and two were developed for western hemlock and mixed conifer types. These five were (1) custodial management, (2) plant only, (3) plant and precommercial thin, (4) genetically improved planting stock with precommercial thinning and fertilization, and (5) management intensity 4 plus commercial thinning. Enrollment rates varied by site productivity class and by ownership. Industrial owners are assumed to shift between 90% and 95% of regenerated acres out of the custodial class, while the same shift for other private owners is about 50% to 55%. On industry lands, generally 55% to 60% of regeneration was to management intensity 4; meanwhile, on other private ownerships, this management intensity received 15% to 30% of regenerated acres. On medium and high site industry lands, management intensity 5 received between 10% and 15% of regeneration, while equivalent sites on other private ownerships received 5%. Depending on ownership and site class, between 20% and 35% of regeneration is split between management intensities 2 and 3.

The alternative management intensity for western hemlock assumed planting and precommercial thinning. The shift on industry lands was between 40% and 70% of regeneration from low to high site classes, while on other private ownerships the parallel shift was between 20% and 50%. The alternate management intensity for the mixed conifer type assumed to be Douglas-fir management intensity 2. For both ownerships and across all site classes, 50% of all mixed conifer regeneration was to Douglas-fir.

Projected Area Changes for Forest Ownerships and Forest Management Types

Projections of timber supply and corresponding prices are sensitive to the assumptions made regarding future forest area. Forest area assumptions include changes in area by ownership, forest management type, and site (Alig et al. 1983). Projections of area changes for the timberland base were made for the North, South, Rocky Mountains and Great Plains, and the Pacific Coast. Within sections, projections were made for two private forest ownership classes—forest industry, and farmer and other private; and public timberland projections were provided by public agency personnel. The area projection methods and results are described in more detail in a supporting technical document (USDA Forest Service 1989), and state level projections are discussed by Alig and others (1990). Projections of timberland area are based on competitive economic returns from land alternative uses, including demographic and public policy influences on economic returns. These projections also considered public programs (e.g. the CRP tree planting program[9]) designed to expand forest area. Other than changes for Indian lands these projections have not been changed for the Assessment Update, and are summarized in table 6. The sensitivity of the forest sector to key, but uncertain, determinants of land use (e.g. changes in agricultural policies) are examined in chapter 4, where we look at an hypothetical scenario dealing with an expanded tree planting program designed to increase the sequestration of atmospheric carbon.

Adjustments for Timber Removals

Estimates of timber harvest (also called roundwood supplies) include removals from several different sources. The most important source (in an inventory accounting sense) are those from growing stock. These include: (1) harvest of roundwood products, such as sawlogs, veneer logs, and pulpwood from growing stock; (2) logging residues; and (3) other removals resulting from noncommercial thinnings, changes in land use such as clearing for cropland, highways or housing developments, and withdrawal of commercial timberland for parks, wildernesses, and other nontimber uses.

The projected supplies (harvest) of roundwood products are internally generated in TAMM/ATLAS. Timber removals are determined by adjusting

[9]*The Conservation Reserve Program (CRP) was intended to convert up to 45 million acres of highly erodible or otherwise environmentally sensitive cropland to permanent cover. The 1990 Farm Bill authorized the continuation up through 1995 of the CRP, which was initiated through the Conservation Title of the Food Security Act of 1985. A total of 2.5 million acres of trees have been planted in the CRP, with owners receiving cost-sharing for establishment costs and annual land rental payments for 10 years. The 1995 Farm Bill will present opportunities through a new conservation title to convert some CRP grassland to trees and to achieve the original goal of planting 12.5% of CRP acres to trees (Soil and Water Conservation Society 1994).*

Table 6.—Area of timberland (in million acres) in the United States, by ownership and region, specified years, 1952 - 1992, with projections to 2040.

Ownership and region	1952	1962	1970[1]	1977[1]	1987[1]	1992	Projections 2000	2010	2020	2030	2040
Ownership											
Public	145.4	146.2	144.2	138.2	131.0	131.5	128.7	128.7	128.7	128.7	128.5
Forest Industry	59.0	61.4	67.6	68.9	70.3	70.5	71.5	71.5	71.4	71.3	71.0
Farmer and other pvt.[2]	304.4	307.5	292.2	285.2	283.6	287.6	275.6	272.5	268.5	265.3	263.1
Total	508.8	515.1	504.1	492.4	484.9	489.6	475.8	472.7	468.6	465.2	462.6
Region											
North	154.3	156.6	154.4	153.4	154.4	157.8	154.4	153.6	151.7	150.5	149.5
South	204.5	208.7	203.3	199.6	197.3	199.3	191.3	190.0	188.6	187.4	186.8
Rocky Mountain	66.6	66.9	64.5	60.2	61.1	62.6	59.9	59.7	59.5	59.4	59.2
Pacific Coast	83.4	82.9	81.8	79.1	72.1	69.8	70.2	69.5	68.7	68.0	67.1
Total	508.8	515.1	504.1	492.4	484.9	489.6	475.8	472.7	468.6	465.2	462.6

Data may not add to totals because of rounding.

[1]*Data were revised after 1989 RPA tables were developed.*

[2]*Indian lands 1952-2040 are now included in Other Private, in past reports were shown in public lands.*

Note: Data for 1952 and 1962 are as of December 31; all other years are as of January 1.

Source: Powell, et al 1993.

the projected timber harvest for removals from non-growing stock sources and then adding estimates of logging residues and other removals. The result is an estimate of the timber removed from growing stock inventory. The data for these three adjustments are derived from the timber product output tables (tables 30 - 32) given in Powell et al (1993).

Logging Residues

Logging residues always have been an important component of timber removals, although they have been declining as a percentage of the total. Between 1952 and 1991, for example, softwood logging residues dropped from about 9.8% of product removals from growing stock - roundwood products plus logging residues - to 7.5%; and hardwood residues fell from 22.2% to 12.0% (table 7). These reductions largely reflect the effects of rising stumpage prices that have made it economical to remove more of the lower quality material that previously was left as logging residues, technological innovations such as in-woods chipping, and rapid growth in the demand for wood in the pulp industry and for industrial fuelwood. These utilization trends will be slowed, to some degree, as management recognizes the broader ecosystem functions of residues: as biological legacies for future stands, wildlife trees, woody debris in streams and riparian zones, and wildlife nesting and cover sites in wetland management zones.

In the East, softwood logging residues as apercentage of product removals from growing stock are about one-half of those in the Pacific Coast regions. In the Pacific Coast states, softwood logging residues were 9.7% of product removals in 1991, the highest in the country. Total hardwood logging residues, 12% of product removals, compose a larger percentage of product removals than for softwoods. This reflects limited markets for much of the low-quality material in the hardwood inventory.

For the projection period, it has been assumed that logging residues from both hardwoods and softwoods will decline as a% of product removals from growing stock in regions with relatively high current proportions. Major factors in these reductions are the expected increases in stumpage prices and intensified competition for wood fiber. This will result in increased use of small stems, chunks, and low-quality stems for fuelwood and pulpwood. Increased tree-length logging and in-woods chipping of pulpwood and fuelwood will reduce residual formation. Another factor is anticipated improvements in felling and bucking practices. The decline in the harvest of old-growth timber in the West and increased use of hardwoods for pulping and as fuelwood also are expected to contribute to the improved utilization.

Table 7.—Logging residues as a percent of timber product removals from growing stock in the United States, by softwood and hardwoods and section, specified years, 1952 - 1991, with projections to 2040.

Ownership and region	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
Softwoods:											
North	11.5	11.0	10.8	11.0	4.6	4.6	4.5	4.5	4.5	4.5	4.5
South	6.6	6.3	6.9	5.9	6.7	6.1	6.0	6.0	5.9	5.9	5.8
Rocky Mountain	10.9	10.9	11.1	11.0	10.8	9.3	9.3	9.3	9.2	9.1	9.0
Pacific Coast[1]	12.2	11.7	12.5	10.2	12.6	9.7	9.7	9.5	9.3	9.1	9.0
United States	9.8	9.6	10.0	8.4	9.0	7.5	7.4	7.4	7.2	7.2	7.1
Hardwoods:											
North	15.8	15.3	15.2	17.2	9.9	9.9	9.0	8.7	8.5	8.5	8.5
South	25.9	24.4	22.6	16.6	15.6	13.6	13.0	12.0	11.3	10.6	10.0
Rocky Mountain	([2])	([2])	([2])	25.0	19.7	8.5	8.5	8.5	8.5	8.5	8.5
Pacific Coast[1]	28.6	26.0	27.4	25.2	7.2	9.0	8.5	8.0	7.6	7.3	7.0
United States	22.2	20.7	19.7	17.1	13.2	12.0	11.3	10.6	10.1	9.7	9.3

[1] *Includes Alaska.*

[2] *Hardwood timber harvests are too small for accurate estimation of logging residues.*

Other Removals

That part of timber removals classified as other removals is composed of (1) losses from timber inventories resulting from the diversion of timberland to other uses such as crop or pasture land, roads, urban areas, parks and wilderness; and (2) timber removed in silvicultural operations such as noncommercial thinning. The historical data on other removals are estimates of actual volumes for specific years (USDA Forest Service 1982, Waddell et al. 1989, Powell et al 1993). Based on the available data, other removals are projected to decline in line with the projected reductions in rates of timberland area conversion to other uses.

Timber Supplies from Non-Growing Stock Sources

Projected timber supplies come primarily from growing stock inventories. Part of the supplies, however, comes from salvable dead trees, rough and rotten trees, tops and limbs, defective sections of growing stock trees in urban areas, fence rows, and on forested lands other than timberland. Output of timber products from nongrowing stock sources has been greatly influenced by markets for pulpwood and fuelwood since the late 1970s.

The proportion of roundwood supply originating from nongrowing stock sources generally dropped between 1952 and 1976 (table 8). Since then, timber product output from nongrowing stock sources has risen from 6.9% in 1976 to 11.9% in 1991 for softwoods, and from 14.0% in 1976 to 37.5% in 1991 for hardwoods. These changes are almost entirely explained by the rapid increase in the use of fuelwood during the past decade.

Among the major geographic regions, there are some trends that differ noticeably from the general U.S. trends. Older forests on the Pacific Coast and in the Rockies contain large volumes of salvable dead timber. With high demand for stumpage, and increasing use of lower quality materials for chips and fuelwood, the proportion of softwood timber supplies coming from nongrowing stock sources on the Pacific Coast is expected to remain greater than in the South.

In the Rocky Mountains, nongrowing stock sources provided 4.5% of the softwood supply in 1976. By 1991, this rose to 14.5%. The significance of nongrowing stock sources was projected to increase through the projection period, as fuelwood continues to be an important product.

Nongrowing stock sources provided about 12.6% of the softwood timber supplies in the North, in 1976. This increased to 26.7% in 1991, and is expected to rise further as fuelwood consumption continues to

Table 8.—Timber product output from nongrowing stock sources as a percent of timber supplies in the United States, by softwoods and hardwoods and section, specified years, 1952 - 1991, with projections to 2040.

Ownership and region	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
Softwoods:											
North	13.3	12.6	12.6	12.6	27.4	26.7	28.0	29.0	30.0	30.0	30.0
South	8.4	8.7	4.5	5.0	4.0	5.3	5.2	5.1	5.0	5.0	5.0
Rocky Mountain	5.8	5.6	4.7	4.5	11.9	14.5	14.5	14.7	14.9	15.0	15.0
Pacific Coast[1]	12.4	11.6	8.9	8.6	17.4	17.2	17.2	17.4	17.6	17.8	18.0
United States	10.4	10.0	7.0	6.9	11.5	11.9	12.0	12.1	12.2	12.3	12.4
Hardwoods:											
North	23.5	17.7	11.9	16.5	51.8	49.4	50.0	50.0	50.0	50.0	50.0
South	19.0	18.9	13.9	11.9	21.9	22.7	23.0	23.5	24.0	24.5	25.0
Rocky Mountains	(2)	(2)	(2)	(2)	79.7	74.0	74.0	74.0	74.0	74.0	74.0
Pacific Coast[1]	14.3	11.5	6.1	11.3	46.2	52.8	50.0	50.0	50.0	50.0	50.0
United States	20.9	18.5	13.9	14.0	38.5	37.5	37.8	38.0	38.3	38.5	38.8

[1]*Includes Alaska.*

[2]*Hardwood timber harvests are too small for accurate estimations of output originating from non-growing stock sources.*

grow. The proportion of softwood nongrowing stock output in the South is low—5.0% in 1976 and 5.3% in 1991. This is expected to remain fairly constant over the next five decades.

Hardwood forests contain large volumes of rough and rotten trees and tops and branches. In the East, hardwoods also make up most of the urban forest, fence rows, and other similar sources of nongrowing stock timber supplies. As a result, a substantial fraction of hardwood roundwood supplies, 37.5% in 1991, came from nongrowing stock sources.

With increasing demand for fuelwood and improvements in techniques for harvesting and processing hardwood for pulp and paper, nongrowing stock is expected to continue to be an important and, in most regions, a growing part of hardwood timber supplies. In the North, for example, the proportion of hardwood timber supplies originating from nongrowing stock was 51.8% in 1986 and 49.4% in 1991.

National Forest Harvest Levels

Harvests from National Forests have been a major source of timber supplies. Harvest projections for these lands in the Update were derived from agency planning activities, including both forest planning efforts and plans for habitat conservation, budget submissions, and the results of court actions such as the June 1991 injunction on timber sales in Forest Service administrative Region 6.[10] These projections assume the implementation of the President's Plan that was developed for the northern spotted owl region by the Forest Ecosystem Management Assessment Team (FEMAT 1993).

Historical levels of total National Forest softwood harvest are shown in the left portion of figure 2 and in table 9. Following World War II, strong demand for forest products and declining private harvests brought expanded markets for National Forest tim-

[10]*United States District Court Western District of Washington at Seattle, Seattle Audubon Society, et al., V. John Evans, et al., No. C89-160ND, Judge William L. Dwyer.*

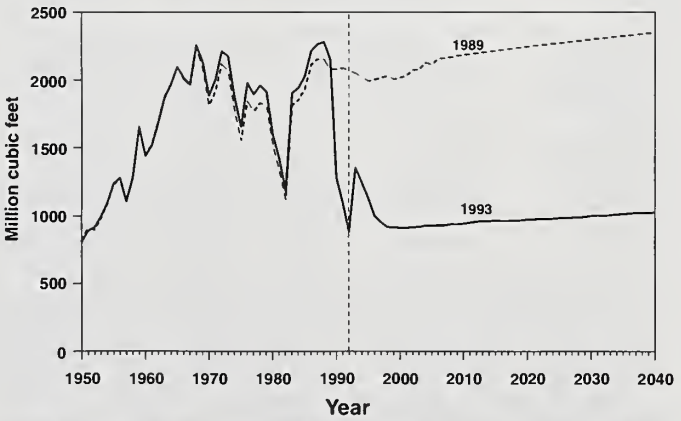

Figure 2.—Total National Forest softwood timber harvest comparing 1989 RPA and 1993 RPA Update.

Table 9.—Softwood removals (in million cubic feet), growing stock inventory, net growth, and harvest for the National Forests ownership, specified years, 1952 -1991 with projections to 2040.

Item and region	1952	1962	1970	1976	1986	1991	Projections 2000[1]	2010	2020	2030	2040
Northeast											
Removals	3	3	3	3	6	5	4	5	5	5	6
Inventory	459	532	637	636	678	723	772	897	1,036	1,190	1,356
Net Growth	13	15	16	18	19	17	17	19	21	22	24
Harvest	3	3	3	2	6	7	6	7	7	7	8
Northcentral											
Removals	22	30	28	34	26	48	35	34	36	39	42
Inventory	1,336	1,988	2,170	2,542	3,270	3,216	3,689	4,488	5,327	6,251	7,187
Net Growth	57	73	75	98	118	84	116	115	125	138	133
Harvest	24	28	34	32	29	56	45	47	49	52	54
Southeast											
Removals	15	28	35	67	74	59	48	49	51	52	53
Inventory	2,074	2,243	2,705	2,946	2,848	2,826	2,511	2,546	2,632	2,745	2,887
Net Growth	80	90	129	137	94	50	50	55	64	65	73
Harvest	14	27	33	61	59	54	44	45	47	48	49
Southcentral											
Removals	145	94	156	181	174	169	131	134	138	142	146
Inventory	3,123	4,874	4,952	5,670	6,466	6,013	5,844	6,276	6,783	7,371	8,028
Net Growth	211	336	314	245	231	174	174	183	197	209	220
Harvest	141	90	147	174	163	163	126	129	133	137	141
Rocky Mountains[2]											
Removals	229	412	524	463	468	389	292	311	331	349	366
Inventory	58,013	62,979	63,825	65,081	70,832	71,657	78,402	88,635	99,274	110,114	121,178
Net Growth	689	776	905	1,044	1,296	1,285	1,285	1,411	1,406	1,490	1,487
Harvest	218	387	480	426	465	425	334	354	374	394	413
Pacific Southwest[3]											
Removals	117	263	378	306	334	314	91	91	92	93	92
Inventory	29,590	29,391	28,694	28,073	27,213	31,448	33,957	37,662	41,541	45,610	49,703
Net Growth	162	186	338	364	422	463	463	456	498	496	504
Harvest	89	216	346	286	347	336	98	99	100	102	101
Douglas-fir subregion											
Removals	364	567	530	525	538	266	96	96	95	95	95
Inventory	47,584	47,704	45,478	44,088	33,607	33,621	33,894	36,073	38,255	40,440	42,630
Net Growth	180	197	240	227	320	320	320	320	320	320	320
Harvest	361	586	489	511	659	297	108	108	108	108	108
Ponderosa pine subregion											
Removals	121	256	314	313	387	330	142	142	141	141	140
Inventory	23,408	25,757	25,911	23,649	17,331	17,338	16,472	17,660	18,849	20,043	21,244
Net Growth	261	310	329	312	269	269	269	269	269	269	269
Harvest	100	232	286	292	378	352	152	152	152	153	152
Alaska											
Removals	13	75	114	95	54	99	95	95	97	98	101
Inventory	38,850	38,228	37,555	35,414	24,068	18,733	16,104	16,063	16,340	16,955	17,699
Net Growth	10	16	20	23	15	85	85	96	160	177	194
Harvest	11	66	100	83	47	99	99	99	99	99	99
United States											
Removals	1,028	1,728	2,082	1,986	2,061	1,681	934	957	986	1,015	1,041
Inventory	204,437	213,696	211,927	208,099	186,313	185,574	191,645	210,300	230,036	250,718	271,911
Net Growth	1,664	1,999	2,367	2,468	2,783	2,747	2,779	2,924	3,061	3,185	3,225
Harvest	961	1,635	1,918	1,867	2,153	1,789	1,011	1,040	1,070	1,099	1,124

[1]*2000 - 2040 inventory based on 1991 inventory and growth data from Powell 1993 and growth rate projections from National Forest plans and harvest and removals numbers from TAMM LR 185.*

[2]*Rocky Mountains region data includes the Great Plain states.*

[3]*Pacific Southwest excludes Hawaii*

Sources: For historical data USDA Forest Service Powell, et al 1993.
Sources: 1991 - 2040 harvest and removal data from TAMM LR 185, growth and inventory data calculated.

ber. The USDA Forest Service shifted from its "custodial" management posture of the inter-war years toward a more active policy of timber sales. Harvest grew rapidly as a result. By the late 1960s, cut was approaching sustainable levels under existing management plans in some areas of the West, and an array of new management priorities brought significant changes in USDA Forest Service supply policies. Volume-based methods (dating back to the 1920s) of harvest scheduling were supplanted, first in 1973 by a nondeclining flow policy, and then in 1976 by the National Forest Management Act (NFMA). As part of NFMA, the Forest Service was required to develop 10-year interdisciplinary forest plans for each administrative unit in the National Forest System. Substantial areas of land were redesignated as wilderness or undeveloped reserves and were removed from the suitable land base. In unreserved areas, harvest planning and practices were modified to minimize adverse environmental impacts and deleterious effects on noncommodity uses of the forest. The consequence of these and other actions stabilized (or in some cases lead to a gradual decline in) harvests over the past 20 years.

A second increase in National Forest harvest between 1985 and 1988 (fig. 2) reflects a one-time drawdown of uncut volume accumulated during the 1981-82 recession and higher harvesting rates of sales made in the mid-1980s. The level of Forest Service timber offered for sale did not change markedly during the 1980s, ranging from a high of 12.2 billion board feet (2.44 billion cubic feet) in 1981 to a low of 10.5 billion board feet (2.10 billion cubic feet) in 1989. Sales totalled some 11.0 billion board feet in (federal fiscal year) 1990. Recent controversies over protection of remaining old-growth on National Forests has led to reductions in the amount offered in some regions. For example, the injunction on timber sales on certain forests in Region 6 reduced timber sales from 3.4 billion board feet (0.7 billion cubic feet) in 1990 to 0.3 billion board feet (0.1 billion cubic feet) in 1991 (Warren 1992).

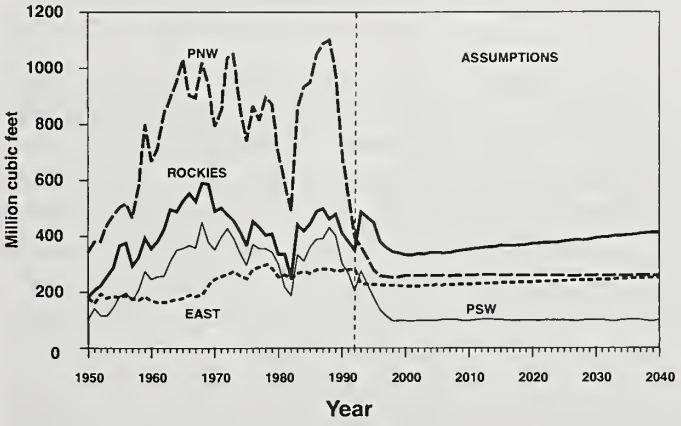

Figure 3.—National Forest softwood harvest by region.

Differences in regional patterns of National Forest harvest, illustrated in the left portion of figure 3, are a reflection of varying rates of regional industrial development and conditions of the National Forest timber resource. The national pattern of figure 2 is derived from the nearly parallel movements of cut in the largest producing areas: the Pacific Northwest, Rocky Mountain, and Pacific Southwest regions. In the wake of rapid industrial expansion and harvest in earlier periods, all of these regions faced significant reductions in private supply during the 1950s and 1960s. Large volumes of mature timber, reasonable wood costs, and an expansive supply policy were ample stimuli for increased National Forest harvest. Harvest limitations since the mid-1960s have been most pronounced in these regions. Harvest patterns in the East are dominated by the Southern states, where private timber supply and output of the solid wood products industry underwent a major contraction during the 1950s. The reduction in timber demand was sufficient to stabilize National Forest harvests as well. With the expansion of the industry beginning in the mid-1960s, harvests from the National Forests increased in line with expanding growth and inventory.

The right hand portions of figures 2 and 3 and table 9 give projections of National Forest softwood harvest; hardwood harvests are shown in table 10. These projections were based on judgements about future allowable sale quantities (plus projections of the nonchargeable harvest) that reflect ongoing policy changes including the adoption of the President's Plan in western Oregon and Washington and northern California, habitat protection for the red cockaded woodpecker, elimination of harvesting in existing roadless areas, and the elimination of below cost timber sales. Projections of total National Forest softwood harvest are 1.0 billion cubic feet per year for 2000 and 1.1 billion cubic feet per year for 2040. These projections are 46% lower in 2000 than those made in the 1989 Assessment. Most of reduction occurs in five states: Montana, Idaho, Washington, Oregon, and California.

Table 10.—Hardwood removals (in million cubic feet), growing stock inventory, net growth, and harvest for the National Forest ownership, specified years, 1952 -1991 with projections to 2040.

Item and region	1952	1962	1970	1976	1986	1991	Projections 2000[1]	2010	2020	2030	2040
Northeast											
Removals	10	11	19	29	13	22	22	23	25	26	26
Inventory	1,983	2,580	3,007	3,749	4,074	3,711	4,303	4,468	4,646	4,872	5,105
Net Growth	69	88	105	117	131	88	86	34	36	42	43
Harvest	9	9	15	21	26	42	40	42	44	46	48
Northcentral											
Removals	28	35	47	49	53	61	76	80	85	88	91
Inventory	2,482	3,491	3,994	4,483	5,470	5,228	5,783	6,087	6,280	6,453	6,578
Net Growth	112	141	140	159	154	123	114	94	86	88	86
Harvest	32	34	40	43	76	95	121	127	133	139	145
Southeast											
Removals	12	18	26	21	14	13	13	13	14	13	13
Inventory	2,784	3,335	3,511	4,679	5,503	5,565	6,480	7,826	9,181	10,540	11,947
Net Growth	73	86	122	141	139	114	112	150	146	144	147
Harvest	9	11	17	15	14	11	11	11	12	12	12
Southcentral											
Removals	61	52	36	26	34	36	32	33	33	34	34
Inventory	1,785	2,793	3,947	3,576	4,502	4,959	5,957	7,116	8,324	9,580	10,918
Net Growth	67	111	122	144	135	147	149	148	151	154	160
Harvest	41	29	32	18	35	37	30	31	32	33	34
West[2]											
Removals	6	11	19	5	45	54	41	42	44	45	47
Inventory	4,522	5,008	5,262	5,080	5,558	6,178	6,338	6,633	6,920	7,190	7,453
Net Growth	74	82	85	97	58	71	71	71	71	71	71
Harvest	9	14	19	4	16	114	79	81	84	86	88
United States											
Removals	117	126	146	130	160	186	184	192	200	205	211
Inventory	13,556	17,207	19,721	21,567	25,107	25,641	28,860	32,129	35,352	38,636	42,001
Net Growth	396	508	573	658	617	544	532	497	491	499	507
Harvest	100	97	123	101	166	299	281	292	305	316	327

[1]*2000 - 2040 North and South inventory based on 1991 inventory and growth data from Powell 1993, harvest data from LR 185, and growth rate projections from National Forest plans.*

[2]*West excludes Hawaii.*

Sources: For historical data USDA Forest Service Powell, et al 1993.
Sources: West growth and inventory data provided by National Forests.

National Forest softwood harvest falls from approximately 1.8 billion cubic feet at present to about 1.1 billion cubic feet by 2040, falling most rapidly over the next decade as management adjusts to the policy changes noted here. After 2000, harvest levels rise slowly. Most of this growth in harvest comes in the East and in the Rockies—particularly in the Northern Region (northern Idaho and Montana). Forest Service hardwood harvest is projected to grow modestly. The Forest Service is not a major supplier of hardwood stumpage, and this position is not expected to change in the future.

The National Forest inventory projections shown in tables 9 and 10 have been revised substantially from the 1989 Assessment. In the 1989 Assessment, National Forest softwood inventories were projected to remain at about 160 billion cubic feet for the next five decades. This estimate (along with estimates of harvests) was provided by the National Forest System (NFS) and was based, in part, on information developed for land management plans. The revision of the NFS inventories is based on inventory, net annual growth, and area data in Powell, et. al. (1993) and NFS harvest projections discussed elsewhere.

The inventories are for timber on available acres, and do not include timber on acres administratively withdrawn from timber harvesting. The projection procedure used a growth drain identity.[11] The starting inventory was increased each year by the net annual growth and decreased by projected removals. Net annual growth and the number of available acres are assumed to be constant throughout the projection period.

The resulting projections should be considered an estimate of the upper limit for NFS inventories. Over time, both the available and suitable acres have declined, and this trend may continue. Net annual growth also may change over time, as new ecosystem management regimes are developed.

For purposes of estimating carbon sequestration or other uses where an estimate of total NFS inventory is needed, it is important to note again that the inventory estimates in tables 9 and 10 are for inventories on available acres. They do not include inventories on NFS areas administratively withdrawn from timber harvesting, such as those acres in wilderness areas.

Other Public Harvest Levels

Other public ownerships comprise a diverse group of public organizations including federal agencies, such as the Bureau of Land Management and Department of Defense, as well as forest land holding entities in city, county and state governments. Historical and projected roundwood supplies, net annual growth, and growing stock inventories are shown in table 11 for softwoods and table 12 for hardwoods. The historical data for 1952-76 were extracted from similar tables in the 1989 Assessment and reflect ownership definitions at that time. The data for 1986 and 1990 were compiled from Waddell et al. 1989, and Powell et al 1993.[12]

Reporting of forest resource statistics for this group has been revised since the 1989 Assessment with the movement of timberland owned by Native American groups (administered by the Bureau of Indian Affairs) from the Other Public to the Other Private owner category. This shift can be seen in the abrupt change in harvest and inventory levels shown in tables 11 and 12 between 1986 and 1991. A further change involved land base, harvest and inventory adjustments on BLM timberlands in Oregon and state lands in Washington, reflecting management changes to protect habitat for the northern spotted owl. Even with these changes, both softwood and hardwood other public inventories are expected to continue to increase during the next five decades. Hardwood inventories increase at a somewhat faster rate than do the softwoods inventories. Only toward the end of the projection period do harvest and growth come into balance for both hardwoods and softwoods. Net growth, especially for hardwoods, is expected to drop as stands mature. The largest reductions in hardwood growth are projected in the next 15 years.

PROJECTED TRENDS IN PROCESSING

No changes were made in projected trends in processing technology, wood use efficiency and related assumptions (other than those noted for pulp and paper). The assumptions used in this Update are those described in the 1989 Assessment.

[11] *The basic form of the growth-drain identity used to update timber inventories was:*

$$I_{t+1} = I_t + G_t - H_t$$

where

G is timber growth, and

H is timber harvest.

All units were expressed in million cubic feet and the time interval was one decade.

[12] *The projections in tables 11 and 12 have been revised from similar projections prepared as part of the Fourth Forest (USDA Forest Service 1988) for the South and for the other regions as part of the last Assessment by first comparing the actual data for 1986 with the projected values for 1986. In the next step, harvest projections from the past studies were judgmentally adjusted by the ratio of projected to actual harvest for 1986. The growth projections were retained from the last Assessment and the value for 2040 was computed as the continuation of the trend between 2000 and 2030. Inventory levels were computed for all projections using a growth-drain identity.*

Table 11.—Softwood removals (in million cubic feet), roundwood supplies, net annual growth, and growing stock inventory for other public ownerships, specified years 1952 - 1991 with projections to 2040.

Item and region	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
Northeast											
Removals	7	6	9	14	16	13	18	19	21	24	25
Harvest	7	5	7	13	18	21	25	29	32	35	36
Net annual growth	27	32	37	49	54	52	54	54	54	53	52
Inventory	885	1,044	1,275	1,555	2,496	2,307	2,647	3,005	3,345	3,656	3,939
Northcentral											
Removals	35	39	43	48	33	29	40	53	54	56	57
Harvest	33	35	38	41	43	37	55	78	79	79	79
Net annual growth	92	120	126	142	168	134	122	122	122	125	129
Inventory	2,162	2,943	3,237	3,728	4,840	4,945	5,790	6,549	7,236	7,923	8,628
Southeast											
Removals	52	45	71	80	120	114	138	141	146	153	153
Harvest	51	43	69	88	100	106	129	132	137	142	142
Net annual growth	70	84	126	149	148	132	136	143	153	165	165
Inventory	1,584	2,089	2,278	2,770	3,639	3,765	3,837	3,836	3,879	3,977	4,104
Southcentral											
Removals	43	32	38	51	74	79	72	71	72	72	72
Harvest	30	30	32	51	64	77	70	70	70	70	70
Net annual growth	56	58	78	71	55	52	52	55	61	86	86
Inventory	780	824	1,225	1,340	1,458	1,876	1,667	1,485	1,352	1,373	1,517
Rocky Mountains[1]											
Removals	79	86	86	93	76	108	131	129	130	130	130
Harvest	72	78	78	85	79	173	212	209	209	209	209
Net annual growth	119	141	162	162	220	171	156	138	136	140	148
Inventory	9,923	10,147	10,399	10,429	11,094	8,352	8,750	8,917	8,993	9,075	9,213
Pacific Southwest[2]											
Removals	5	18	27	24	15	11	17	18	18	18	18
Harvest	3	16	26	22	12	13	20	21	22	22	22
Net annual growth	14	14	14	14	25	24	23	25	27	30	33
Inventory	1,892	1,435	1,150	1,108	1,245	953	1,042	1,112	1,191	1,292	1,424
Douglas-fir subregion											
Removals	155	274	359	439	419	226	247	246	245	244	243
Harvest	158	290	343	428	418	258	284	284	284	284	284
Net annual growth	193	316	356	371	495	449	425	479	562	659	635
Inventory	20,085	19,787	19,610	19,161	19,576	19,474	21,278	23,327	26,073	29,730	33,762
Ponderosa Pine subregion											
Removals	52	64	103	96	102	34	38	46	47	48	49
Harvest	48	61	97	89	77	81	92	112	114	116	120
Net annual growth	66	88	91	96	139	48	46	48	51	55	59
Inventory	7,792	6,536	6,483	6,748	7,027	2,565	2,658	2,702	2,729	2,783	2,862
Alaska											
Removals	1	4	14	6	3	3	5	6	7	7	8
Harvest	1	4	12	5	3	3	4	5	6	6	7
Net annual growth	93	108	123	137	67	68	85	69	47	36	28
Inventory	10,081	10,915	11,864	12,200	5,880	5,765	6,419	7,135	7,650	7,991	8,235
United States											
Removals	429	568	750	851	858	616	705	729	741	752	755
Harvest	403	562	702	822	814	769	890	939	953	964	969
Net annual growth	730	961	1,113	1,191	1,371	1,130	1,099	1,132	1,214	1,348	1,335
Inventory	55,184	55,720	57,521	59,039	57,255	50,002	54,088	58,069	62,450	67,800	73,683

[1]*Rocky Mountains region historical data (excluding harvest) includes the Great Plains states.*

[2]*PSW exludes Hawaii.*

Data for 1952 - 1986 contain Indian lands, 1991 - 2040 Indian land data has been transferred to Other Private.

Source: For historical data USDA Forest Service Powell, et al 1993.

Source: Projection data for removals (1991-2040) and harvest (2000-2040) are from TAMM LR 185, growth and inventory calculated.

Table 12.—Hardwood removals (in million cubic feet), roundwood supplies, net annual growth, and growing stock inventory for other public ownerships, specified years, 1952 - 1991 with projections to 2040.

Item and region	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
Northeast											
Removals	24	30	37	30	28	70	33	34	34	34	34
Harvest	23	26	28	23	23	62	62	62	62	62	62
Net annual growth	142	182	210	238	265	200	188	186	182	176	172
Inventory	3,803	4,838	5,697	6,478	9,110	9,333	10,612	12,145	13,646	15,097	16,501
Northcentral											
Removals	44	55	77	87	74	154	75	76	76	75	75
Harvest	45	51	70	72	81	117	117	117	117	117	117
Net annual growth	213	270	278	304	341	270	277	276	276	279	286
Inventory	4,583	6,619	7,649	8,343	10,112	10,193	11,624	13,637	15,643	17,666	19,743
Southeast											
Removals	15	16	29	34	36	35	35	35	35	34	33
Harvest	12	10	20	31	62	30	30	30	30	30	30
Net annual growth	27	32	55	71	86	88	87	82	85	99	99
Inventory	845	1,155	1,547	1,992	3,006	3,359	3,831	4,324	4,809	5,387	6,044
Southcentral											
Removals	50	40	35	52	62	44	59	59	59	57	56
Harvest	33	36	36	53	66	56	56	56	56	56	56
Net annual growth	55	71	90	109	101	128	102	98	111	132	132
Inventory	1,365	1,750	2,106	2,401	3,307	4,552	5,122	5,527	5,985	6,626	7,385
Rocky Mountains[1]											
Removals	2	4	3	2	2	1	1	1	1	1	1
Harvest	2	2	1	1	1	2	2	2	2	2	2
Net annual growth	8	9	10	11	27	17	11	11	10	8	12
Inventory	566	624	670	682	974	689	805	906	1,003	1,082	1,172
Pacific Southwest[2]											
Removals	1	2	2	2	1	1	1	1	1	1	1
Harvest	1	1	1	2	1	2	2	2	2	2	2
Net annual growth	6	5	7	7	16	13	5	5	4	4	4
Inventory	218	190	263	283	554	407	481	524	563	597	631
Douglas-fir subregion											
Removals	5	3	13	15	14	19	24	24	24	25	25
Harvest	5	3	9	12	35	34	34	34	34	34	34
Net annual growth	33	57	91	92	84	62	40	43	45	50	46
Inventory	1,080	1,526	2,030	2,263	2,360	2,502	2,768	2,941	3,139	3,373	3,608
Ponderosa Pine subregion											
Removals	(3)	(3)	(3)	(3)	1	1	1	1	1	1	1
Harvest	1	1	1	1	1	1	1	1	1	1	1
Net annual growth	1	1	1	1	4	1	1	1	1	1	1
Inventory	55	58	59	59	82	71	68	64	60	56	52
Alaska											
Removals	(3)	(3)	3	3	5	2	6	6	7	7	7
Harvest	(3)	(3)	4	4	6	6	7	7	8	8	8
Net annual growth	7	7	7	7	55	55	78	67	39	19	10
Inventory	3,902	3,861	3,873	3,864	1,751	1,751	2,314	2,979	3,444	3,665	3,739
United States											
Removals	141	150	199	225	222	326	234	235	236	233	231
Harvest	122	130	170	199	276	309	310	310	312	312	312
Net annual growth	492	634	749	840	978	834	788	769	754	769	763
Inventory	16,417	20,621	23,894	26,365	31,256	32,857	37,623	43,047	48,292	53,549	58,874

[1]*Rocky Mountains region historical data (excluding harvest) includes the Great Plains states.*

[2]*PSW exludes Hawaii.*

[3]*(3) Less than 0.5 million cubic feet.*

Source: For historical data USDA Forest Service Powell, et al 1992.

Source: Projection data for removals and harvest is from TAMM LR 185, growth and inventory calculated.

One of the primary objectives of this Update is to project possible future changes in the Nation's demand for timber products and in the domestic timber resource base that supplies a substantial part of our consumption requirements. These projections provide a means of identifying current, emerging, and future problems in the timber resource sector, and analyzing the economic, social, and environmental implications of alternative policies and programs addressing these problems. Resource projections presented here are also of value as a basis for public discussion of individual and collective perceptions of the future of the forest resource — perceptions that ultimately will influence stewardship and industrial decisions.

Update projections are derived directly from the assumptions on major determinants of changes in demand and the timber resource described in the preceding chapter. The projections change as these assumptions are modified. There is no intent to portray the trends projected here as socially or economically desirable or undesirable. Indeed, the economic, social, and environmental implications of these trends may stimulate actions to change them.

This chapter presents the **base** projections of future market activity for both product and stumpage markets. In broad terms, the base projection is intended to represent an outlook in which past trends in most of the economic determinants of timber and forest products supply continue in a fixed policy environment. Specifically the base projection assumes that: (1) population and general economic conditions in the U.S. develop as discussed in chapter 2; (2) forest land area, private investment in forest management, and developments in most wood processing technologies follow recent historical trends; and (3) public policies regulating management on both private and public forest lands remain fixed in the forms and structures observed in the early 1990s.

The base case provides a datum against which to measure the impacts of alternative assumptions on economic and policy developments. Although the general economic elements of the projection represent a reasonable view of the future, the base case is **not** intended to represent the "most likely" or "most probable" future outlook. Because of the importance of public policy in the behavior of forest products markets and forest management practices, a "most likely" forecast would be wholly inappropriate in a document designed to provide science-based information for policy decision-making.

All projections in this chapter are made at equilibrium price levels.[13] That is, prices are allowed to change until the quantities supplied and demanded are equal.

PROJECTED CONSUMPTION, PRODUCTION, TRADE AND PRICES FOR TIMBER PRODUCTS

Consumption, production, trade and prices for the various classes of forest products are projected to follow somewhat diverse trends over the next five decades, driven, in large part, by the effects of substitution and limited timber supplies.

Lumber

Lumber consumption in all uses in 1990 was 56.7 billion board feet (table 13). This was almost 40% above average consumption in the 1950s and 1960s, but about 3 billion board feet less than the peak levels reached in 1988. Consumption of lumber is projected to rise throughout the projection period, reaching 74.0 billion board feet in 2040. This is an increase of 8% over the 1989 Assessment. New housing, traditionally the largest single end use for lumber, declines in importance over the projection. Reflecting both the higher costs of new housing and the advancing age of the existing housing stock, residential upkeep and alteration becomes the largest use after 2010, absorbing one-quarter of total lumber consumption.

In 1990, softwood species comprised nearly 82% of all lumber consumed; this percentage is expected to change little over the projection period. In some end uses of lumber, such as shipping (pallets) and manu-

[13] *In this study, equilibrium prices and quantities are determined by the intersection of supply and demand curves. The equilibrium prices are those prices at which the amount willingly supplied and the amount willingly demanded are equal. These prices and the associated equilibrium timber supply-demand projections were developed by means of regionally desegregated economic simulation models. For further details, see: Adams and Haynes (1980), Haynes and Adams (1985) and Binkley and Cardellichio (1986).*

Table 13.—Lumber consumption in the United States (in billion board feet), by species groups, end use, specified years 1962-1991, with projections to 2040.

Year	Species group			End use					
	Total	Soft-woods	Hard-woods	New housing	Residential upkeep & improv-ments	New non-resident construct	Manu-fac-turing	Shipping	All other
1962	39.1	30.8	8.5	14.5	4.4	4.2	4.5	4.6	6.9
1970	39.9	32.0	7.9	13.3	4.7	4.7	4.7	5.7	6.8
1976	44.7	36.6	8.0	17.0	5.7	4.5	4.9	5.9	6.7
1986	57.0	48.0	9.0	19.3	10.1	5.3	4.8	6.8	10.9
1990	56.7	45.9	10.8	16.6	11.6	5.3	5.9	8.1	9.1
2000	58.1	46.9	11.1	15.1	13.4	6.2	5.3	9.3	8.7
2010	62.4	50.5	11.9	14.7	15.5	6.7	5.8	10.3	9.5
2020	68.6	56.0	12.7	16.2	17.5	7.4	6.3	10.8	10.5
2030	71.9	58.6	13.3	14.9	19.0	8.1	7.1	11.1	11.7
2040	74.0	60.0	14.0	13.7	20.1	8.9	7.9	11.3	12.2

Note: Data may not add to totals because of rounding.

facturing (furniture), a slow increase in the proportion of hardwoods is expected.

Trade in lumber products is dominated by softwood lumber imports from Canada (table 14). Between 1952 and 1986, softwood lumber imports (nearly all from Canada) rose from 2.3 billion to 14.2 billion board feet. The largest part of this increase occurred during the 1976-1986 period. Hardwood lumber imports are expected to remain constant throughout the next five decades.

Like softwood lumber imports, softwood lumber exports have increased since the early 1950s. Most of the growth has consisted of shipments to Japan, South and Central America, and Western Europe. Softwood lumber exports are expected to be stable after 2010, at about 3 billion board feet. Hardwood lumber exports also have grown, and are expected to stabilize at about 1.5 million board feet. The slowing in the growth of exports is associated with the price increases in the U.S. relative to those in other producing regions.

While total U.S. production of lumber rises steadily over the projection period (table 14), regional patterns of output vary markedly (table 15). For softwood lumber, declining public timber harvest in the West leads to substantial near-term reductions in lumber production in the Pacific NW, Pacific SW and Northern Rockies regions. These losses are partly absorbed by increased imports, as noted previously, and also by a dramatic shift in output from the West to the South. As indicated in table 15, softwood lumber production in the two Southern regions is projected to rise by more than 50% between 1991 and 2000 to some 19.4 billion board feet. This increase is already underway, with 1993 Southern softwood output reported at 14.4 billion board feet.

After the major adjustments of the 1990s, projected regional trends for softwood lumber parallel changes in the private softwood timber resource. Production in the Pacific NW stabilizes, then begins to rise on the strength

Table 14.--Lumber consumption (in billion board feet), imports, exports, and production in the United States 1960-1991 with projections to 2040.

Year	Consumption			Imports			Exports			Production		
	Total	Softwood lumber	Hardwood lumber	Total	Softwood lumber[1]	Hardwood lumber	Total	Softwood lumber[1]	Hardwood lumber	Total	Softwood lumber	Hardwood lumber
1960	37.7	29.6	8.1	3.9	3.6	0.3	0.9	0.7	0.2	34.7	26.7	8.0
1970	39.9	32.0	7.9	6.1	5.8	0.3	1.2	1.1	0.1	35.0	27.3	7.7
1976	44.7	36.6	8.0	8.2	8.0	0.3	1.8	1.6	0.2	38.3	30.3	8.0
1986	55.8	47.0	8.8	14.5	14.2	0.3	2.4	1.9	0.5	43.7	34.7	9.0
1990	56.7	45.9	10.8	12.4	12.2	0.2	3.8	3.0	0.8	48.0	36.6	11.4
2000	58.1	46.9	11.1	13.7	13.4	0.4	4.5	3.0	1.5	48.8	36.5	12.3
2010	62.4	50.5	11.9	15.4	15.0	0.4	4.5	3.0	1.5	51.5	38.5	13.0
2020	68.6	56.0	12.7	17.1	16.7	0.4	4.6	3.1	1.5	56.1	42.3	13.8
2030	71.9	58.6	13.3	15.9	15.5	0.4	4.6	3.1	1.5	60.5	46.1	14.4
2040	74.0	60.0	14.0	15.3	14.9	0.4	4.6	3.1	1.5	63.3	48.1	15.2

[1]*Includes small volumes of mixed species not classified as softwoods or hardwood.*
Note: Data may not add to totals because of rounding.

Table 15.--Lumber production (in billion board feet, lumber tally), in the contiguous States, by softwoods, hardwoods and region, 1952-1991 with projections to 2040.

Species group & region	1952	1962	1970	1976	1986	1990	Projections 2000	2010	2020	2030	2040
Softwoods											
Northeast	1.3	0.8	0.6	0.8	1.4	1.5	1.8	2.0	2.0	2.0	2.0
Northcentral[1]	0.4	0.3	0.3	0.4	0.3	0.3	0.6	0.8	0.9	0.8	0.8
Southeast	5.2	2.7	2.8	3.4	5.2	5.7	9.9	11.8	11.6	9.2	9.2
Southcentral	3.6	3.2	4.2	4.6	6.1	6.5	9.5	9.5	11.9	16.4	16.1
Rocky Mtn.	2.5	3.6	4.2	4.5	4.5	5.0	4.7	4.2	4.4	4.8	5.4
Northern Rockies	1.6	2.8	2.9	3.1	3.4	3.5	3.1	2.5	2.6	2.9	3.4
Southern Rockies	0.9	1.0	1.2	1.2	1.3	1.3	1.6	1.7	1.8	1.9	2.0
Pacific NW[2]											
Douglas-fir subregion[3]	10.3	8.6	7.4	8.4	9.2	9.1	5.2	5.8	7.0	7.6	8.5
Ponderosa Pine subregion[4]	2.3	2.4	2.3	2.7	2.8	2.9	2.3	2.5	2.8	3.0	3.3
Pacific SW[5]	4.6	5.0	5.1	4.8	5.1	5.4	2.4	1.9	1.7	2.1	2.7
Total U.S.											
Softwoods	30.2	26.6	26.9	29.5	34.6	36.4	36.5	38.5	42.3	46.1	48.1
Hardwoods											
Northeast	0.9	1.0	1.4	1.8	2.0	2.5	2.6	2.6	2.7	2.8	3.1
Northcentral[1]	2.4	1.2	1.5	2.4	2.8	3.4	3.2	3.1	3.0	3.0	3.1
Southeast	1.6	1.5	1.7	1.3	1.8	2.5	3.1	3.5	3.8	4.0	4.2
Southcentral	2.3	2.6	2.5	1.7	2.4	2.7	3.1	3.6	3.9	4.3	4.6
West	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Total U.S.											
Hardwoods	7.2	6.4	7.2	7.4	9.2	11.3	12.3	13.0	13.8	14.4	15.2

[1]*Includes Great Plains.*

[2]*Excludes Alaska.*

[3]*Western Oregon and western Washington.*

[4]*Eastern Oregon and eastern Washington.*

[5]*Excludes Hawaii.*

Note: Data may not add to totals because of rounding.

of growing inventories and harvests (and stabilizing timber prices) from maturing industrial plantations. This same process is repeated in the Pacific SW and Northern Rockies regions, but not until the 2010-2020 period. In the Southeast, lumber output continues to rise through 2010, then declines paralleling the projected decline in nonindustrial private timber inventories in the region that reduces private harvest despite major increments from industrial ownerships. These same developments are observed in the Southcentral region, but not until after 2030, when inventories and harvests begin to decrease on all private lands.

Regional shares of hardwood lumber production shift in response to changing cost conditions, just as do softwoods, but with less dramatic changes over the projection. Most of the increase in hardwood lumber production is in the South, accounting for 58% of total production by 2040. Production in the North remains fairly stable. These results for hardwoods are essentially the reverse of those presented in the 1989 Assessment, where much of the future expansion in hardwood lumber production came in the North. While the North does play a larger role in the pulp industry in the Update, reducing to some extent inventories that might be used for sawtimber, the primary cause of this change in projections was a revised analysis of private sawtimber supply decisions. Analysis now suggests that, despite rising inventories and prices for hardwoods, nonindustrial owners in the North will not respond with much increase in harvest. This is largely the result of an highly diverse ownership structure and ownership objectives that increasingly deemphasize income production from timber harvest.

Structural Panel Products

Structural panels (softwood plywood and oriented strandboard and waferboard) consumption reached 26 billion square feet (3/8-inch basis) in 1986—83% above the volume consumed in 1970 and nearly 3 times total use in 1962 (table 16). Consumption declined slightly in 1991 because of the 1990-1991 recession. Until the late 1970s, softwood plywood was the only structural panel in wide use. Primarily because of its substitution for softwood lumber in an array of sheathing, siding, and underlayment applications, softwood plywood growth was particularly fast in the 1950s and 1960s. Oriented strandboard and waferboard, in turn, have proven to be significant substitutes for softwood plywood for sheathing uses in both residential and nonresidential construction and other applications. Growth in softwood plywood consumption has slowed substantially as a result.

Projections of total structural panel consumption rise to 42.3 billion square feet in 2040, about 70% above 1990 consumption (table 16), 7.6% greater than the level projected in the 1989 Assessment. All of the increase over the projection period results from continued growth in oriented strandboard consumption, which is projected to reach 27.0 billion square feet by 2040, more than four times its use in 1986. Plywood consumption slowly declines to 15.3 billion square feet in 2040. As a result of these trends, oriented strandboard and waferboard panels comprise almost 64% of total structural panel consumption in 2040, up sharply from about 25% in 1990. Consumption of panels is expected to increase across all end uses, except for new housing and the all other category (table 16).

Imports of oriented strandboard and waferboard from Canada increased rapidly in the late 1970s as demand growth outpaced domestic production expansion (table 17). Imports are expected to peak in 2000, and begin a modest decline in the face of rapid expansion of domestic capacity.

Table 16.—Structural panel consumption (in billion square feet, 3/8 inch basis) in the United States, by panel type, end use, specified years 1962-1991, with projections to 2040.

	Panel type			End use					
Year	Total	Softwood plywood	OSB/waferboard	New housing	Residential upkeep & improvements	New nonresident construct	Manufacturing	Shipping	All other
1962	9.5	9.5	0.0	4.0	1.0	1.7	0.7	0.2	1.9
1970	14.2	14.2	0.0	5.6	2.4	1.9	0.9	0.3	3.2
1976	18.0	17.7	0.2	7.8	3.3	1.9	1.1	0.3	3.6
1986	26.0	21.7	4.3	10.0	6.2	3.1	1.3	0.4	5.1
1990	25.0	18.8	6.2	9.0	6.0	3.5	2.3	1.6	1.8
2000	28.9	17.0	12.0	9.7	6.9	4.0	2.8	2.1	3.4
2010	32.2	15.9	16.3	9.8	7.9	4.5	3.6	2.7	3.7
2020	36.7	15.6	21.1	11.2	8.9	4.9	4.5	3.5	3.7
2030	39.4	15.4	24.0	10.4	9.7	5.4	5.9	4.6	3.4
2040	42.3	15.3	27.0	9.6	10.4	6.0	7.6	6.0	2.8

Note: Data may not add to totals because of rounding.

Table 17.--Structural panel consumption (in billion square feet, 3/8 inch basis), imports, exports, and production in the United States, specified years 1960-1991, with projections to 2040.

	Consumption			Imports			Exports			Production		
Year	Total	Softwood plywood	OSB/waferboard	Total	Softwood plywood	OSB/waferboard	Total	Softwood plywood	OSB/waferboard	Total	OSB/Softwood plywood[1]	waferboard
1960	7.8	7.8	(2)	(2)	(2)	(2)	(2)	(2)	(2)	7.8	7.8	(2)
1970	14.2	14.2	(2)	(2)	(2)	(2)	0.1	0.1	(2)	14.3	14.3	(2)
1976	18.0	17.7	0.2	0.2	(2)	0.1	0.7	0.7	(2)	18.5	18.4	0.1
1986	25.3	20.8	4.5	0.9	0.1	0.8	0.6	0.6	(2)	24.8	21.2	3.6
1991	24.3	17.9	6.4	1.5	(2)	1.5	1.3	1.3	(2)	24.1	19.2	4.9
2000	29.0	17.0	12.0	2.1	(2)	2.1	1.6	1.6	(2)	28.4	18.5	9.9
2010	32.3	15.9	16.4	1.7	(2)	1.7	1.7	1.7	(2)	32.2	17.5	14.7
2020	36.8	15.6	21.2	1.6	0.1	1.5	1.9	1.9	(2)	37.3	17.3	20.0
2030	39.3	15.4	23.9	1.5	0.1	1.4	2.0	2.0	(2)	39.8	17.3	22.5
2040	42.3	15.3	27.0	1.6	0.1	1.6	2.0	2.0	(2)	42.6	17.2	25.4

[1] *Includes production from both domestic and imported species.*

[2] *Less than 50 million square feet.*

Note: Data may not add to totals because of rounding.

Table 18.--Structural panel production (in billion square feet, 3/8 inch basis) in the contiguous States by region, 1952-1991 with projections to 2040

Region	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
Northeast	0.0	0.0	0.1	0.1	0.6	0.6	1.8	3.3	4.5	5.0	5.7
Northcentral[1]	0.0	0.0	0.0	0.1	1.5	2.2	3.6	4.7	5.7	6.0	6.4
Southeast	0.0	0.0	0.9	1.7	3.8	4.0	4.6	4.9	5.3	5.5	5.8
Southcentral	0.0	0.0	2.4	5.1	8.2	8.9	9.4	9.8	10.7	11.6	11.9
Rocky Mtn.	0.0	0.2	0.9	1.2	1.5						
Northern Rockies						1.3	1.3	1.3	1.3	1.3	1.3
Southern Rockies						0.3	0.3	0.4	0.5	0.5	0.6
Pacific NW[2]											
Douglas-fir subregion[3]	2.7	7.9	8.5	8.9	8.2	6.0	5.8	5.7	5.9	5.9	6.0
Ponderosa Pine subregion[4]	0.0	0.2	0.8	0.9	0.8	0.9	1.5	2.1	3.1	3.8	4.7
Pacific SW[5]	0.3	1.2	0.8	0.6	0.3	0.1	0.1	0.1	0.1	0.1	0.1
Total United States	3.0	9.5	14.4	18.6	24.9	24.3	28.4	32.3	37.1	39.7	42.5

[1]*The Great Plains are included in the Northcentral region.*

[2]*Excludes Alaska.*

[3]*Western Oregon and western Washington.*

[4]*Eastern Oregon and eastern Washington.*

[5]*Excludes Hawaii.*

Note: Data may not add to totals because of rounding.

Exports of softwood plywood, though showing some fluctuation, increased strongly in the mid-1980s as the result of efforts to increase the penetration of European and other markets. Exports are expected to rise more slowly in the future because of lower economic growth in these markets. Exports of oriented strandboard and waferboard are expected to remain small.

Domestic production of structural panels is projected to grow apace with U.S. consumption (table 17); and the regional pattern of production, which has undergone major shifts since the start of Southern pine plywood production in 1964, will continue to change (table 18). During the past decade, the North became a major structural panel producer through expansion of oriented strandboard and waferboard capacity (table 18). We project more than a four-fold increase in Northern OSB/waferboard output by 2040. In the West, the base projection suggests that the long-term decline of the softwood plywood industries in the Pacific SW and Douglas-fir regions may be at an end. High wood costs, however, will prevent these regions from participation in the OSB/waferboard market. Throughout the West, only the ponderosa pine subregion appears to have significant potential for expansion in OSB/waferboard. Production continues to grow in the South (in OSB/waferboard only), but not as rapidly as in the past 15 years. As a consequence, the South's share of total structural panel production declines from 53% in 1991 to 42% by 2040, while the North's share rises from 12% to 28% over the same period. The Pacific Coast region retains about 25% of the market by 2040, because of projected OSB expansion in the Ponderosa Pine region.

Nonstructural Panel Products

Nonstructural panels consumption, including hardwood plywood, insulating board, hardboard, and particleboard, rose to 22.2 billion square feet (3/8-inch basis) in 1990, more than 3 times total use in 1960 (table 19). Projected total demand for nonstructural panels increases to 24.8 billion square feet in 2000 and 28.4 billion square feet by 2040, about 7% higher than those in the 1989 Assessment.[14]

[14]*Few changes were made in the end-use factor projections for nonstructural panels in this Update, so that most changes from the 1989 Assessment are the consequence of revised projections of GNP and other economic variables.*

Table 19.--Nonstructural panel consumption, imports, exports, and production (in billion square feet, 3/8 inch basis) in the United States, specified years 1960-1991, with projections to 2040.

Year	Consumption					Imports				
	Hardwood Total	Insulating plywood	Hard-board	Particle-board	Hardwood board[1]	Insulating Total	Hard-plywood	Particle-board	board	board[1]
1960	6.5	1.8	3.8	0.7	0.5	0.9	0.7	0.1	0.1	([2])
1970	13.2	3.8	4.3	1.6	3.5	2.3	2.0	0.1	0.2	([2])
1976	16.9	3.4	4.5	2.1	6.9	2.7	2.4	0.1	0.2	0.1
1986	18.2	4.5	3.8	2.0	9.0	3.8	3.7	0.5	0.3	0.3
1990[2]	22.2	3.8	4.0	3.3	11.1	2.6	1.6	0.4	0.3	0.3
2000	24.8	4.2	4.4	4.0	12.2	2.6	1.7	0.3	0.3	0.3
2010	25.8	4.5	4.4	4.5	12.4	2.6	1.7	0.3	0.3	0.4
2020	27.3	5.1	4.6	5.2	12.4	2.6	1.7	0.3	0.3	0.4
2030	27.0	4.8	4.4	5.6	12.2	2.6	1.7	0.3	0.3	0.4
2040	28.4	5.0	4.6	5.9	12.9	2.6	1.7	0.3	0.3	0.4
	Exports					Production				
1960	0.1	([3])	([3])	([3])	([3])	6.1	1.1	3.8	0.6	0.5
1970	0.2	0.1	0.1	([3])	([3])	11.0	1.8	4.3	1.4	3.5
1976	0.4	0.1	0.1	0.1	0.2	14.6	1.1	4.5	2.0	7.0
1986	0.6	0.1	0.2	0.1	0.3	15.0	0.8	3.5	1.7	9.0
1990	0.6	([3])	0.2	0.1	0.3	20.2	2.2	3.8	3.1	11.1
2000	0.4	([3])	0.1	0.1	0.2	22.6	2.5	4.2	3.8	12.1
2010	0.6	([3])	0.1	0.2	0.3	23.7	2.8	4.2	4.4	12.3
2020	0.6	([3])	0.1	0.2	0.3	25.2	3.4	4.4	5.1	12.3
2030	0.6	([3])	0.1	0.2	0.3	24.9	3.1	4.2	5.5	12.1
2040	0.6	([3])	0.1	0.2	0.3	26.3	3.3	4.4	5.8	12.8

[1]*Includes medium density fiberboard.*

[2]*Data for 1991 is not summarized.*

[3]*Less than 50 million square feet.*

Note: Data may not add to total because of rounding.

Because future trends in major markets vary, as do prospective rates of market penetration and product substitution, somewhat different trends in demand are projected for the various products. Little growth is expected in insulating board, whose major market is residential construction. Hardwood plywood, used in manufacturing as well as construction, increases slowly through 2040, while particleboard rises until 2010, but shows little growth afterwards. Hardboard is the only nonstructural panel product to show a steady increase throughout the projection period.

Imports of hardwood plywood are the most important trade flow in the nonstructural panels group. Currently, about two-thirds of all the hardwood plywood consumed in the United States is imported, chiefly from Taiwan and Indonesia. Imports from these and other sources rose rapidly until the mid-1980s. Since then, they have fallen to 1.6 billion square feet per year (Nolley 1992). In the future, imports are expected to stabilize at 1.7 billion square feet per year. No other notable changes are expected in the trade flows for these products.

Paper and Board

On a per capita basis, annual paper and board consumption climbed from about 360 pounds per person in 1952 to nearly 550 pounds in 1970, and to more than 600 pounds in 1973. Rapid growth in paper and board consumption during this period was driven by strong growth in the economy, with substantial increases in consumption of paper and board in packaging, printing and writing, and sanitary grades. The 1970s and 1980s witnessed continued but generally slower growth in per capita con-

sumption, reaching a record level of nearly 700 pounds by the late 1980s. During the early 1990s, per capita consumption actually declined slightly.

In terms of national totals, consumption and production of paper and board has steadily increased since the 1950s (table 20), as have both imports and exports. While projections indicate that future consumption will grow at a far more modest pace, per capita use will exceed 900 pounds by the year 2040. Exports will continue to increase, but imports are projected to gradually decline as increased recycling extends fiber supplies and contributes to reduced dependence on imported paper and board products.

Following the trend in paper and board consumption, wood fiber use in the production of paper and board grew rapidly in the decades immediately following World War II. The pace began to slacken in the 1970s and 1980s (table 21), partly because of substantial increases in the consumption of recovered (recycled) paper in the mix of fibers used to produce paper and board. Still larger increases are projected in the base case during the decade of the 1990s and beyond. Projections of paper recycling rates are higher in this Update than in the 1989 RPA Assessment. The tonnage of recovered paper which was recycled and used in the production of paper and board at U.S. mills amounted to 25% of paper and board production in 1986. In 1992, this **wastepaper utilization rate** (the ratio of tons of recycled paper used in paper and board production to tons of total paper and board output) had climbed to 30%, and it continues to increase.[15] This Update projects that the waste paper utilization rate will reach 40% shortly after the year 2000, and will exceed 45% by the year 2040 (Ince 1994). Projected increases in paper recycling result in slower projected growth in woodpulp consumption.

Table 20.—Paper and board consumption, exports, imports, and production in the United States, specified years, 1952-1991, with projections to 2040.

Year	Consumption		Exports	Imports	Production
	Total	Per capita			
	1,000 tons	*Pounds*		*1,000 tons*	
1952	29,092	369	499	5,173	24,418
1962	42,360	454	1,003	5,820	37,543
1970	55,968	546	2,817	7,115	51,670
1976	62,014	569	3,457	7,142	58,329
1986	79,755	663	4,687	11,936	72,505
1991	84,900	672	7,043	12,167	81,064
2000	95,920	705	8,204	10,534	93,590
2010	106,645	733	10,355	9,468	107,532
2020	120,005	782	12,893	9,512	123,389
2030	136,873	861	16,034	9,873	143,035
2040	148,910	911	18,595	8,575	158,931

Note: Data may not add to totals because of rounding.

Table 21.—Wood fiber consumption (thousand tons) in U.S. paper and board production, specified years, 1952-1991, with projections to 2040.

Year	Total wood fiber	Woodpulp	Wastepaper
1952	25,167	17,286	7,881
1962	37,673	28,598	9,075
1970	54,995	43,192	11,803
1976	61,163	47,541	13,622
1986	75,727	57,792	17,935
1991	85,592	62,079	23,513
2000	98,815	62,539	36,276
2010	114,264	68,295	45,969
2020	131,214	76,700	54,515
2030	152,235	86,950	65,285
2040	170,792	95,017	75,775

Note: Data may not add to totals because of rounding.

Woodpulp consumption in the United States has more than doubled on a per capita basis since 1952, but projections indicate much less rapid future growth (table 22). Exports of woodpulp are projected to increase, but imports are projected to decline as increased recycling will reduce dependence on fiber imports. Given these developments, U.S. production of woodpulp is projected to increase by about 65% between 1991 and 2040.

Pulpwood

Slower growth in woodpulp production resulting from rising rates of wastepaper utilization is directly reflected in reduced growth in pulpwood supply and harvests. While total U.S. pulpwood supply more than doubled between 1960 and 1991, it is projected to increase by only about 50% between 1991 and 2040 (table 4). Over the next two decades, hardwood will account for the bulk of pulpwood supply growth. The lower cost of hardwood, particularly in the east-

[15] *Another way of viewing the wastepaper utilization rate is that a rate of, say, 30% means that 30% of all paper and board produced is derived from recycled fibers.*

ern United States, will favor continued technological substitution of hardwood for softwood, in line with historical trends. Hardwood substitution and increased recycling will result in very modest growth in softwood pulpwood consumption and harvest. Beyond the year 2010, declining hardwood timber inventories will act to constrain hardwood pulpwood supplies and raise hardwood costs, particularly in the South. As a result, the softwood share of pulpwood input will rise and softwoods will account for most of the projected growth in pulpwood supply.

Other Industrial Timber Products

A variety of other industrial timber products are consumed in the United States, including: poles, piling, posts, round mine timbers, bolts used for shingles, handles, and woodturnings, chemical wood and the roundwood used for oriented strandboard and waferboard and particleboard not manufactured from byproducts. Total consumption of roundwood for these products amounted to an estimated 0.8 billion cubic foot in 1990. Board products (such as OSB/waferboard) accounted for 37% of the roundwood consumed in this category in 1990, and will be responsible for the bulk of the category's future growth.

Table 22.—Wood pulp consumption, exports, imports and production in the United States, specified years, 1952-1991, with projections to 2040.

	Consumption				
Year	Total	Per capita	Exports	Imports	Production
	1,000 tons	*Pounds*		*1,000 tons*	
1952	18,198	231	212	1,937	16,473
1962	29,511	316	1,186	2,789	27,908
1970	43,969	429	3,095	3,518	43,546
1976	48,930	449	2,518	3,727	47,721
1986	58,552	484	4,458	4,582	57,802
1991	62,820	497	6,338	4,997	64,418
2000	63,256	465	6,616	2,123	67,749
2010	68,999	474	7,636	1,931	74,704
2020	77,375	504	8,703	1,088	84,989
2030	87,534	551	10,330	362	97,502
2040	95,470	584	11,910	372	107,008

Note: Data may not add to totals because of rounding.

While not included in the volume total for other industrial products, log trade is a major product in some regions. Imports of logs, both softwood and hardwood, have been, and are expected to remain a small component of total supply. Exports of softwood logs, largely from the Pacific Northwest to Pacific Rim markets, are expected to continue. This trade flow has been the subject of great controversy over the past three decades, and a variety of restrictions have been imposed on the exportation of logs from public timberlands. In 1992, exports amounted to about 2.2 billion board feet, down from the all time peak of 3.7 billion board feet reached in 1988 (Warren 1994). Future softwood log exports (reflecting only **current** export restrictions) from Washington, Oregon, and California are expected to remain at the 2.2 billion-board-foot level through 2040.

Within this stable total, the mix of exports by destination is projected to change. Future shipments to Japan are likely to decline in line with a contracting Japanese housing market, while shipments to rapidly growing economies in Korea, Taiwan, and other parts of Asia are expected to expand. The ultimate affect of demand from the People's Republic of China, currently exporting half as much as Japan, continues to be difficult to assess. This Update, like other studies (Perez-Garcia 1993), takes a conservative view and assumes that exports to China remain constant at current levels. On the supply side, there are substantial potentials for growth of softwood log exports from Chile and New Zealand (by the late 1990s) and the Soviet Union (after 2000) that might act as substitutes for logs from the Pacific Northwest. We believe these flows will primarily impact the markets for pulpwood and low grade lumber and logs, however, and not compete directly with the higher quality saw/veneer log flows from the northwestern U.S. (Flora and Vlosky 1986, Perez-Garcia 1993). Finally, exports of hardwood logs, about 200 million cubic feet in 1990, are projected to remain at that level over the projection period.

Product Price Projections

The product price trends projected in table 23 reflect the effects of the many forces acting to shift demand and supply for products over time. Analysis of the relative movements in these several factors provides a basis for explaining the projected trends. In the case of softwood lumber, prices are expected to

Table 23.—Deflated price[1] indexes for selected timber products in the United States, by softwoods and hardwoods, 1952-1990, with projections to 2040.

Product, unit & species group	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
					Index of price per unit - 1982 = 100						
Lumber (1,000 board feet)											
Softwoods	99.8	88.3	95.3	126.0	114.3	113.0	139.3	148.1	160.2	155.8	163.1
Hardwoods	104.7	103.7	118.6	109.9	126.2	127.2	163.4	188.7	210.0	224.5	241.2
Structural panels (1,000 square feet, 3/8-inch basis)											
Plywood	172.0	119.0	109.2	143.6	121.1	94.2	106.4	112.5	124.6	126.3	133.8
OSB-waferboard	156.3	104.0	99.2	111.1	100.3	118.7	114.0	94.3			
Non-structural panels (1,000 square feet, 3/8-inch basis)											
Plywood	184.5	174.5	53.4	110.6	90.7	NA	88.4	86.7	85.0	83.3	81.6
Other panels[2]	151.4	115.0	92.1	107.1	NA	107.1	107.1	107.1	107.1	107.1	
Paper and paperboard (Metric tonne)											
Paper	93.2	102.8	105.1	104.2	106.8	98.9	91.2	89.9	91.5	93.0	95.8
Paperboard	130.4	121.1	107.6	112.9	106.3	118.7	102.3	105.2	101.0	93.9	97.5

[1]*Prices are measured in constant (1982) dollars and are net inflation or deflation. They measure price changes relative to the general price level and most competing materials.*

[2]*Hardboard, particleboard, and fiberboard products.*

NA = Not available.

rise rapidly until 2020, averaging about 1.2% per year, then about stabilize for the remainder of the projection. Price growth in the early part of the projection results from rising stumpage costs in lumber production (with only limited change in demand) during the period to 2010, followed by a modest upturn in housing demand during the 2010-2020 period (the "baby-boom echo"). As discussed in further detail in a later section, the stumpage price increases in the 1990-2010 period, in turn, result from declining public harvests in the West (1990-2000), followed by stable to declining harvest on key private ownerships in the South (2000-2010). After 2020, major inventory and harvest increases on industrial private ownerships in both the West and South stabilize stumpage costs and product prices as well.

This scenario of future softwood lumber prices is similar in pattern to the long-term historical trend of lumber prices. Since 1900, the price of lumber, measured in constant dollars, has risen at an average rate of 1.4% per year. Periods of price growth, however, have not occurred at uniform intervals. Typically, there have been periods of one to two decades when prices showed little change (for example, the 1950s). This has been followed by periods, such as the 1940s and 1970s, when prices rose rapidly.

Equilibrium hardwood lumber prices rise, in a steady fashion, at an average annual rate of about 1.3% per year over the projection. This reflects the regular growth in demand for hardwoods in shipping uses (primarily pallets) and, after 2010, a steady decline in both hardwood inventory and harvests on the key Southern nonindustrial private ownerships.

The equilibrium projections for structural panel prices (table 23) show rising real prices for plywood but stable prices for oriented strandboard and waferboard. For the entire projection period, softwood plywood prices increase at about 0.5% per year. Plywood stumpage costs are driven by thesame factors as softwood lumber; therefore, some upward pressure on price is expected. At the same time, softwood plywood will continue to face extensive competition and substitution from OSB/waferboard, and any upward price movements result in market loss. The

interaction of these two considerations yields the limited but steady price growth projected. In contrast, price projections for OSB/waferboard show little change over the projection period. This is the consequence of very limited growth in wood costs because of lower wood input quality requirements.

Little change is projected for the prices of nonstructural panels. Real prices of hardwood plywood are expected to continue to decline (at a decreasing rate) throughout the projection period. Prices for the other board products are expected to remain constant in real terms.

Projected paper and paperboard prices exhibit a different trend than most of the solid wood products. In general, paper and paperboard prices are expected to remain about constant over the next 50 years. Among other things, this reflects the effects of increased recycling that extends fiber supplies and enhances competitiveness of U.S. producers (these projections show that the U.S. becomes a net exporter of paper and paperboard products). Pulp and paper prices exhibit a tendency to rise and fall with business cycles, and prices for several grades have been rising in the past year, especially market pulp prices. But, without some major demand shift (for example, a shift away from substitution of electronic media and plastics for paper and board products), per capita consumption for most paper and board products should increase only gradually from around 700 pounds at present to 900 pounds in 2040.

THE STUMPAGE MARKET

Projected Consumption and Harvest of Timber

The projections of timber products consumption in previous sections have been presented, for the most part, in standard units of measure, such as board feet of lumber, square feet of panel products, cords of pulpwood and fuelwood, and cubic feet of miscellaneous industrial roundwood. To aggregate the wood volumes consumed in the manufacture of these products and to estimate the associated timber harvests, these projections are converted to a common unit of measure—cubic feet of roundwood. Rates of conversion vary by product, region, species, and over time, reflecting the projected wood utilization efficiencies of the industries involved and our estimates of future changes in technology and type of timber processed.

Consumption of Roundwood

In 1991, total U.S. consumption of timber products in terms of roundwood volume was 18.7 billion cubic feet, including fuelwood obtained from nongrowing stock sources (table 24).[16] Total consumption of timber products is projected to increase to 20.4 billion cubic feet in 2000, and 26.5 billion cubic feet in 2040, an average growth rate of about 0.6% per year over the next 50 years. The growth rate for hardwoods will be higher than that for softwoods, particularly in the period prior to 2010, as hardwood use in pulping grows sharply. Pulpwood and fuelwood show the largest increases in volume. By 2040, these two products account for 47% of the timber consumed in the United States. Miscellaneous products exhibits the largest increase on a percentage basis, because of the growth in roundwood used for oriented strandboard and waferboard. Wood use for veneer remains constant or declines relative to 1991 levels for both softwoods and hardwoods.

These results differ from the 1989 and past Assessments, showing substantially lower volumes of wood consumed in pulping. The 1989 RPA Assessment, for example, projected an increase of some 5 billion cubic feet of pulpwood by 2040. The higher levels of recycling used in this Update eliminate these large increases in pulpwood harvest.

Part of this total consumption is met by trade with other countries. The scale of this trade relative to consumption and U.S. harvest can be seen in table 25. In 1991, nearly 20% of total demand was filled by imports. Total imports in 1991 amounted to 2.8 billion cubic feet, almost double the volume imported in 1952. Over the same period, exports rose more than 22 times, to 2.2 billion cubic feet.

Projected levels of total imports change little over the projection because of compensating shifts in component products: increases in lumber and panel products are offset by declining imports of pulp and paper products. Total hardwood imports rise in the near term but return to current levels by 2040. Projected total exports increase about 13% to 2.5 billion cubic feet in 2040 as a result of general increases in exports of all products. Exports of hardwood prod-

[16] *Inclusion of fuelwood from non-growing stock sources is consistent with conventions used in past Assessments. The 1983 Assessment Supplement (Haynes and Adams 1985) and the South's Fourth Forest Study (USDA Forest Service 1988), however, did not include non-growing stock fuelwood in their estimates of total roundwood consumption.*

Table 24.—Apparent roundwood consumption (in billion cubic feet, roundwood equivalent) in the United States, by species group and product, specified years 1952-91, with projections to 2040.

Species group and product	Historical						Projections				
	1952	1962	1970	1976	1986	1991	2000	2010	2020	2030	2040
Softwoods											
Sawlogs[1]	5.2	4.8	5.3	6.0	7.7	6.6	7.5	8.0	8.7	8.9	9.0
Veneer logs	0.2	0.7	0.9	1.2	1.4	1.1	1.0	0.9	0.9	0.9	0.9
Pulpwood[2]	1.8	2.5	3.0	2.8	3.2	3.3	2.8	2.6	3.1	3.7	4.4
Miscellaneous products[3]	0.4	0.2	0.2	0.2	0.3	0.3	0.5	0.7	0.9	1.1	1.1
Fuelwood	0.5	0.2	0.1	0.1	0.5	0.5	0.7	0.9	0.9	0.8	0.9
Total	8.1	8.4	9.5	10.4	13.1	11.8	12.5	13.1	14.5	15.4	16.3
Hardwoods											
Sawlogs[1]	1.1	1.1	1.1	1.1	1.9	1.9	2.0	2.1	2.2	2.3	2.5
Veneer logs	0.2	0.2	0.3	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2
Pulpwood[2]	0.3	0.7	1.0	1.1	2.0	2.2	2.2	2.6	2.8	2.7	2.6
Miscellaneous products[3]	0.4	0.2	0.2	0.1	0.2	0.2	0.6	0.7	0.9	0.9	1.0
Fuelwood	1.7	0.9	0.4	0.5	2.6	2.5	2.9	3.1	3.2	3.5	3.9
Total	3.7	3.1	3.0	3.0	6.9	6.9	7.9	8.7	9.3	9.6	10.2
All species											
Sawlogs[1]	6.3	5.9	6.4	7.1	9.6	8.5	9.5	10.1	10.9	11.2	11.5
Veneer logs	0.4	0.9	1.2	1.5	1.6	1.2	1.2	1.1	1.1	1.1	1.1
Pulpwood[2]	2.1	3.2	4.0	3.9	5.2	5.5	5.0	5.2	5.9	6.4	7.0
Miscellaneous products[3]	0.8	0.4	0.4	0.3	0.5	0.5	1.1	1.4	1.8	2.0	2.1
Fuelwood	2.2	1.1	0.5	0.6	3.1	3.0	3.6	4.0	4.1	4.3	4.8
Total	11.8	11.5	12.5	13.4	20.0	18.7	20.4	21.8	23.8	25.0	26.5

[1]*Includes log exports.*

[2]*Includes both pulpwood and the pulpwood equivalent of the net trade of chips, pulp, paper, and board.*

[3]*Includes cooperage logs, poles, piling, fence posts, round mine timbers, box bolts, shingle bolts, roundwood used in waferboard, oriented strand board, and particleboard manufacture, and other miscellaneous items.*

Table 25.—Apparent roundwood consumption (in billion cubic feet), exports, imports, and roundwood harvest on forestland in the United States, by species group, specified years 1952-91,[1] with projections to 2040.

Species group and product	Historical[1]						Projections				
	1952	1962	1970	1976	1986	1991	2000	2010	2020	2030	2040
Softwoods											
Total consumption[2]	8.1	8.4	9.5	10.4	13.1	11.8	12.5	13.1	14.5	15.4	16.3
Exports	0.1	0.4	1.3	1.6	1.2	1.6	1.7	1.6	1.6	1.7	1.7
Imports	1.3	1.7	2.1	2.5	2.7	2.3	3.1	3.3	3.6	3.5	3.4
Harvest from U.S. Forestland	6.9	7.1	8.7	9.5	11.6	11.1	11.1	11.4	12.5	13.6	14.6
Hardwoods											
Total consumption[2]	3.7	3.1	3.0	3.0	6.9	6.9	7.9	8.7	9.3	9.6	10.2
Export	0.0	0.1	0.2	0.2	0.3	0.6	1.0	1.0	1.0	0.9	0.8
Imports	0.1	0.2	0.3	0.3	0.6	0.5	0.5	0.4	0.4	0.3	0.3
Harvest from U.S. Forestland	3.6	3.0	2.9	2.9	6.6	7.0	8.4	9.3	9.9	10.2	10.7
All species											
Total consumption[2]	11.8	11.5	12.5	13.4	20.0	18.7	20.4	21.8	23.8	25.0	26.5
Exports	0.1	0.5	1.5	1.8	1.5	2.2	2.7	2.6	2.6	2.6	2.5
Imports	1.4	1.9	2.4	2.8	3.3	2.8	3.6	3.7	4.0	3.8	3.7
Harvest from U.S. Forestland	10.5	10.1	11.6	12.4	18.2	18.1	19.5	20.7	22.4	23.8	25.3

[1]*Data are estimates of actual consumption and harvests.*

[2]*Total demand for products converted to a roundwood equivalent basis.*

ucts are projected to rise 50%, to about 0.8 billion cubic foot over the projection period.

The net trade situation differs between the hardwood and softwood sectors. The softwood sector is expected to remain a net importer of timber products. The primary imports are expected to remain softwood lumber and newsprint, both from Canada. The hardwood sector, in contrast, is a net exporter of timber products. These projections of timber products imports and exports show no real change from the 1989 Assessment in terms of net imports into the United States.

Harvests from U.S. Timberland

Given the projections of total consumption and net trade (tables 14, 17, 19, and 20), harvests of U.S. timber will continue to rise over the next five decades, from 18.1 billion cubic feet in 1990 to 25.3 billion in 2040 (table 25), some 41%. Demands for both softwoods and hardwoods increase; hardwoods by 51%, to 10.7 billion cubic feet, and softwoods by 35% to 14.6 billion cubic feet.

This general picture differs little from that described in the 1989 Assessment. Because of the higher paper recycling projections, the projected harvest from U.S. forests in 2040 is 7% lower in the Update than the 1989 Assessment, even with the generally higher levels of product demands in the Update. Softwood harvest is 8% lower by 2040 in the Update, while the hardwood harvest is 6% lower. The hardwood difference is smaller than softwoods because of increasing use of hardwood relative to softwood fiber for pulp and paper products.

Projected Sawtimber Stumpage and Pulpwood Prices

Projections of regional stumpage prices[17] for softwood sawtimber[18] are summarized in table 26 and shown for selected regional aggregates in figure 4. Prices rise substantially in all regions at about the same rates as in the 1989 Assessment. Increases are most rapid over the next 25 years, as the major producing regions adjust to a sequence of timber supply limitations. With more liberal supplies beginning in 2015, prices are nearly stable in most regions.

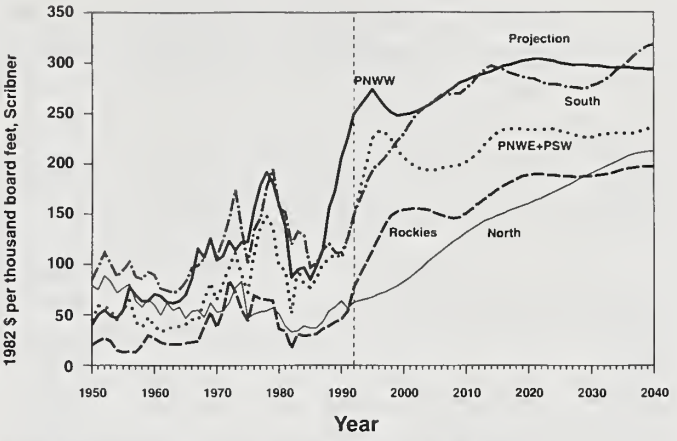

Figure 4.—Softwood sawtimber stumpage prices.

The western regions have experienced very rapid stumpage price increases in recent years because of declining public timber harvests. The base projections (fig. 4) for these regions all show a price peak and subsequent decline in the period prior to 2005. These movements reflect the effects of increasing competition for shrinking timber supplies: rising stumpage prices and production costs, declining profitability in the initial phase, and the ensuing contraction of regional processing capacity (and price) as firms leave the industry. The PNWW (Douglas-fir) region has seen the most rapid price growth in the West. The base projections indicate, however, that the largest increases may have taken place already. As a consequence, average price growth over the 1991-2040 period is only 0.5%. The capacity adjustment process is likely to continue to force major price increases in the near-term in the California ponderosa pine and Rockies regions, with long-term growth averaging 1.3% and 2.7%, respectively, over the next five decades.

Near-term softwood stumpage prices in the Eastern regions rise fairly steadily with the gradual shift of timber demand from the West. In the South, stumpage prices have lagged well behind those in the western regions, despite rapid growth in wood products output. The price differential is projected to gradually disappear during the 1990s, however, as still larger increments in Southern output are realized. Between 2005 and 2015, the South will provide

[17] *All stumpage prices are measured in 1982 dollars. This excludes the effects of general price inflation or deflation. The increases shown, therefore, measure change relative to the general prices of most competing materials.*

[18] *The definition of sawtimber here does not follow the traditional one given in Powell et al (1993). Rather sawtimber is defined as that part of harvest used in the manufacture of lumber, plywood, and miscellaneous products and as log exports.*

Table 26.—Stumpage prices[1] in the contiguous States, by region, 1952-1991, with projections to 2040.

Region	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
					Price per thousand board feet, Scribner log rule						
Softwoods-sawtimber											
North	90	60	54	51	25	49	82	132	160	190	212
South	129	108	120	141	103	121	234	265	285	272	324
North Rocky Mountains	28	23	41	74	31	55	182	164	221	209	216
South Rocky Mountains	25	16	32	59	30	55	92	105	116	127	149
Pacific Northwest[2]											
Douglas-fir Subregion[3]	54	63	105	156	99	254	248	283	302	298	291
Ponderosa Pine Subregion[4]	66	39	60	105	93	125	203	198	234	221	228
Pacific Southwest[5]	54	39	66	114	82	134	208	194	247	244	236
					Price per thousand board feet, international 1/4" scale						
Hardwoods-sawtimber											
North		72	76	77	91	94	121	122	131	145	161
South		31	45	58	42	40	65	77	95	112	131
					Price per cubic feet						
Delivered pulpwood											
Softwoods											
North					0.97	0.95	1.06	1.05	1.25	1.38	1.70
South					0.77	0.84	0.70	0.64	0.66	0.82	1.01
West					0.71	1.01	0.94	0.75	0.79	0.93	0.91
Hardwoods											
North					0.75	0.77	0.66	0.74	0.78	0.79	0.86
South					0.67	0.69	0.61	0.71	0.87	1.08	1.34
West					0.77	1.10	1.02	0.81	0.86	1.36	1.32

[1]*Prices are measured in constant (1982) dollars and are net of inflation or deflation. They measure price changes relative to the general price level and most competing materials.*

[2]*Excludes Alaska.*

[3]*Western Oregon and western Washington.*

[4]*Eastern Oregon and eastern Washington.*

[5]*Excludes Hawaii.*

Sources: Data for 1952, 1962, 1970, 1976, and 1986 based on information published by the U.S. Department of Agriculture and summarized by Adams, Jackson, and Haynes (1988).

the primary basis for rising timber prices in the U.S., as it faces timber supply constraints of its own on private lands. Over the 1991-2040 period, Southern stumpage price growth will average 1.9% per year. Prices in the North rise steadily over the projection period, reflecting slow but continued growth in demand for softwood timber and stable to declining softwood inventories on private ownerships. Between 1991 and 2040 annual growth averages 2.7%.

Hardwood sawtimber prices are expected to increase between 1.0 and 2.4% per year between 1991 and 2040, as shown in table 26. A portion of the projected increase in stumpage prices derives from general growth in the demand for hardwood sawtimber (and indirectly the growth in demand for hardwood pulpwood). In the North, stumpage price growth is augmented by limited increments in harvest on nonindustrial ownerships despite rapidly rising inventories. This reticence to harvest timber reflects increases in the number of these owners and in the diversity of their objectives for holding forest land and their decreasing reliance on income from forest harvesting. This same phenomenon is observed in the South, but to a lesser extent. Southern harvests

increase sharply leading to long-term supply limitations (and upward price pressure) as inventories on nonindustrial lands are drawn down.

Projected pulp prices also are shown in table 26. Near-term pulpwood prices decline in all regions but in the North, because of the impact of recycling on the demand for fiber. After 2010, pulpwood prices begin to increase more rapidly as recycling rates stabilize. The differences in the trends for sawtimber and pulpwood prices are illustrated for the South in figure 5. In general pulpwood prices reflect the relatively constant real price trends for paper and paperboard products (table 23).

Projected Regional Harvest Volumes

Harvest volumes associated with the foregoing stumpage price projections are shown in table 27. Near-term reductions in western harvest because of declining public cut and the limited availability of merchantable timber on private lands is clearly seen in the Pacific NW, Pacific SW, and Northern Rockies regions. By 2040, all western regions see some resurgence in harvest, as private young-growth inventories reach merchantable ages.

In the South, after nearly three decades of growth, softwood harvests about stabilize in the 2000-2015 period. Stumpage prices rise and growth in regional solid wood product output stalls as a result. After 2015, growth in softwood harvest resumes, reflecting the maturation of large areas of plantations.

Regional shares of softwood harvest change modestly but noticeably over the projection. Western regions consistently decline in importance, because

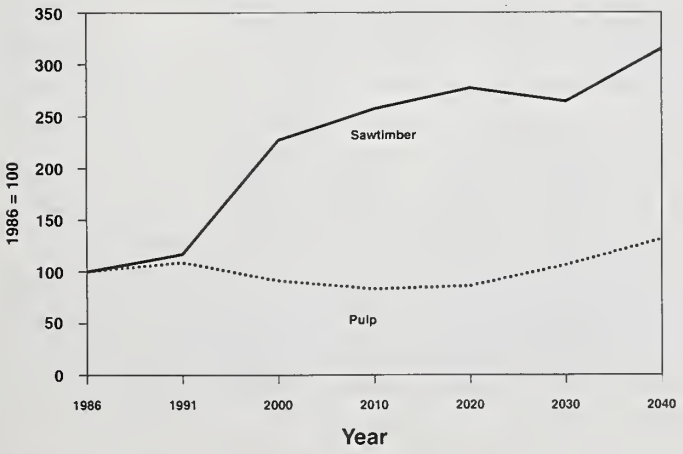

Figure 5.—Softwood price trends in the South.

only in a few cases does private harvest grow sufficiently by 2040 to compensate for public harvest reductions during the 1990s. The combined South and North, in contrast, rise from 59% of total U.S. harvest in 1991 to some 69% by 2040. The largest gain is in the South (from 50% to 58%), and occurs primarily in the final decades of the projection. Hardwood harvest is expected to increase in all regions, although not uniformly. The largest increases are in the South, where growth in both hardwood lumber and pulpwood production pushes up harvest. The lowest rate of growth in the East is in the Northcentral subregion.

Changes in harvest are accompanied by shifts in the average diameter of trees harvested. Projected average harvest diameters of timber on private timberlands in the various Assessment regions are shown in table 28. Decreasing sizes of future harvests are expected in most regions in both hardwoods and softwoods, but these changes will be smaller than those experienced during the past two decades. In the Pacific Coast region, reductions in average harvest diameters in the past reflected the shift in the concentration of cutting from old-growth to older second-growth stands that regenerated naturally after early cutting. In the South, size reductions have accompanied the shift from stands of natural origin to more intensively managed plantations. In the future, average harvest diameters on the Pacific Coast will continue to fall as cutting shifts heavily into intensively managed plantation stands. In table 28, the proportional changes in size are about the same in both the South and Pacific Coast states.

TRENDS IN TIMBER GROWTH AND INVENTORIES

Rising future harvests of both softwoods and hardwoods, as projected in table 27, will both impact and be impacted by the levels and rates of growth of the timber inventory across all owners and regions. Projections of harvest, growth and inventory for the base case are shown in tables 29-32 for private timberlands. Similar data for the public timberlands were given in tables 9-12. Projections are summarized for all regions and owners in tables 33 and 34.

Total softwood inventories (for all owners and regions) are projected to increase by 131 billion cubic feet or some 29% between 1991 and 2040 (fig. 6). Most

Table 27.—Timber harvests (billion cubic feet of roundwood supplies) from forestland in the contigous states, by region, specified years 1952 - 1991, with projections through 2040.

Item	1952[1]	1962[1]	1970[1]	1976[1]	1986[1]	1991	Projections 2000	2010	2020	2030	2040
Softwoods											
Northeast	0.48	0.37	0.38	0.43	0.60	0.67	0.82	0.95	1.00	1.01	1.03
North Central[2]	0.17	0.20	0.17	0.21	0.24	0.27	0.39	0.48	0.51	0.52	0.51
Southeast	1.65	1.40	1.63	1.72	2.33	2.36	2.95	3.14	3.22	3.04	3.26
South Central	1.21	1.16	1.96	2.28	2.80	2.92	3.32	3.25	3.86	4.85	5.22
Rocky Mountain	0.47	0.61	0.79	0.85	1.01	1.00	0.95	0.89	0.94	1.01	1.13
North Rocky Mountains	0.31	0.44	0.56	0.61	0.69	0.68	0.59	0.51	0.53	0.57	0.64
South Rocky Mountains	0.16	0.17	0.23	0.24	0.32	0.32	0.36	0.38	0.41	0.44	0.49
Pacific Northwest[3]											
Douglas-fir subregion (Western Washington and Western Oregon)	1.85	2.01	2.44	2.69	3.14	2.09	1.70	1.75	1.92	2.00	2.13
Ponderosa Pine subregion (Eastern Washington and Eastern Oregon)	0.38	0.50	0.48	0.54	0.60	0.55	0.49	0.54	0.63	0.68	0.77
Pacific Southwest[4]	0.68	0.86	0.85	0.78	0.78	0.86	0.48	0.41	0.42	0.50	0.60
Softwoods total harvests	6.89	7.11	8.70	9.50	11.50	10.72	11.10	11.41	12.50	13.62	14.63
Hardwoods											
Northeast	0.55	0.55	0.54	0.52	1.52	1.67	1.99	2.18	2.36	2.55	2.82
Northcentral	0.98	0.80	0.75	0.81	1.93	2.01	2.26	2.38	2.47	2.58	2.75
Southeast	0.77	0.62	0.63	0.64	1.35	1.28	1.61	1.77	1.81	1.78	1.78
Southcentral	1.27	0.96	0.89	0.84	1.58	1.63	2.18	2.56	2.74	2.72	2.79
West	0.03	0.07	0.09	0.09	0.29	0.38	0.41	0.46	0.51	0.55	0.56
Hardwoods total harvests	3.60	3.00	2.90	2.90	6.67	6.97	8.45	9.34	9.89	10.18	10.70

[1]*Data are estimates of actual consumption or harvests and differ somewhat from the "trend" estimates shown in the preceding section on timber supplies.*

[2]*Includes the Great Plains States - Kansas, Nebraska, North Dakota, and South Dakota.*

[3]*Excludes Alaska.*

[4]*Excludes Hawaii.*

Note: Data include fuelwood, and may not add to totals because of rounding.
Sources: The historical data are published in Adams, Jackson, and Haynes (1988).

Table 28.—Average diameter[1] (in inches) of timber harvested on private timberlands in the Assessment regions.

	Pacific Coast		Rocky Mountains		North		South	
	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood[2]
1976	—	27.5	—	16.9	13.3	11.3	13.7	13.1
1986	16.6	18.7	18.9	9.6	14.2	12.0	12.4	9.9
1990	16.4	17.9	17.5	9.5	14.0	12.0	12.1	10.7
2000	16.8	16.5	14.1	9.3	13.5	12.1	11.4	9.5
2040	16.5	15.5	12.7	9.3	14.1	12.2	10.8	9.0

[1]*Diameter measured at breast height.*

Table 29.-Softwood removals, harvest, net annual growth, and growing stock inventory (in million cubic feet) on Forest Industry timberlands[1] in the contiguous States, 1952-1991 with projections to 2040.

Item	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
Northeost											
Removals	105	92	138	182	273	317	321	228	180	172	169
Horvest	99	87	128	168	356	384	470	362	284	262	250
Net Growth	179	236	339	377	188	188	178	170	170	170	183
Inventory	5,246	6,427	9,753	10,824	9,191	9,608	7,498	6,378	6,378	6,026	6,051
Northcentrol[2]											
Removols	34	23	28	33	37	31	53	61	64	45	42
Horvest	30	22	25	28	41	52	67	82	86	58	53
Net Growth	43	44	63	55	50	42	52	53	54	56	57
Inventory	917	1,314	1,521	1,690	1,653	1,664	1,746	1,686	1,591	1,578	1,702
Southeost											
Removals	325	262	458	518	821	870	1,060	1,326	1,300	1,135	1,249
Horvest	318	252	430	473	740	747	964	1,209	1,187	1,044	1,155
Net Growth	375	411	558	688	725	761	1,150	1,463	1,606	1,609	1,543
Inventory	6,803	7,809	8,670	9,142	10,717	10,750	11,988	13,952	16,370	20,508	24,576
Southcentrol											
Removols	494	341	564	898	1,088	1,271	1,091	1,043	1,925	2,787	2,587
Horvest	484	328	530	893	1,045	1,096	1,050	1,006	1,855	2,680	2,497
Net Growth	707	971	889	894	829	924	1,236	2,045	2,161	2,333	2,440
Inventory	9,738	13,087	13,501	14,430	13,515	13,306	12,331	20,741	27,625	27,359	24,291
Pocific Southwest											
Removols	456	449	318	344	435	401	148	154	85	147	249
Horvest	393	385	294	321	452	452	170	195	124	202	329
Net Growth	90	108	135	139	205	244	189	169	174	198	198
Inventory	11,268	9,639	8,244	7,457	7,918	9,051	5,102	5,144	5,299	5,954	5,865
Douglos-fir subregion											
Removols	1,150	909	1,272	1,302	1,222	901	799	857	1,015	1,079	1,118
Horvest	1,244	976	1,234	1,268	1,244	1,106	924	989	1,164	1,243	1,307
Net Growth	337	393	455	606	915	804	913	992	1,095	1,177	1,195
Inventory	32,725	27,399	23,767	21,978	20,137	17,921	17,719	19,374	20,811	22,022	22,912
Ponderoso Pine subregion											
Removals	103	95	120	162	179	151	150	139	145	135	136
Harvest	100	94	117	151	166	100	178	190	219	221	234
Net Growth	62	71	84	85	115	101	148	134	139	131	149
Inventory	3,975	3,972	4,038	3,849	4,279	3,842	5,116	4,965	4,882	4,764	4,879
United Stotes											
Removols	2,666	2,171	2,898	3,439	4,055	3,942	3,621	3,809	4,715	5,501	5,550
Horvest	2,668	2,144	2,758	3,302	4,043	3,936	3,823	4,033	4,918	5,710	5,825
Net Growth	1,793	2,234	2,523	2,844	3,027	3,063	3,867	5,026	5,400	5,673	5,764
Inventory	70,672	69,647	69,494	69,370	67,410	66,142	61,500	72,240	82,957	88,211	90,276

[1]*The Forest Industry timberlands in the Rocky Mountains are included with the Farmer and Other Private Timberlands for that region.*

[2]*Data for the Great Plains are included in the Rocky Mountains for the historical period and in the North Central subregion for the projection period.*

Note: Supply data for 1952, 1962, 1970, 1976, 1986, ond 1991 are estimotes of the trend level of horvests ond differ somewhat from the estimotes of actual consumption shown in some tobles. For the projection years, the dota shows the volume that would be horvested given the ossumptions of the study. Inventory doto for 1952 ond 1962 are as of December 31. Inventory data for 1970 and the projection yeors ore os of Jonaury 1. Inventory data shown under 1976, 1987, ond 1991 are os of Jonuory 1 of following year.
Source: For historicol dota USDA Forest Service Powell, et al 1993.
Source: All projection dato from TAMM LR 185.

Table 30.—Hardwood removals, harvest, net annual growth, and growing stock inventory (in million cubic feet) on Forest Industry timberlands[1] in the contiguous States, 1952-1991 with projections to 2040.

Item	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
Northeast											
Removals	47	51	91	121	110	256	166	187	203	213	226
Harvest	44	45	69	89	216	253	319	361	391	419	450
Net Annual Growth	129	156	193	226	230	233	212	209	209	211	213
Inventory	4,742	5,554	6,819	7,636	8,835	9,090	10,556	10,868	11,003	11,013	10,942
Northcentral2											
Removals	74	45	64	69	142	119	77	68	78	93	112
Harvest	73	41	57	55	201	258	127	114	132	160	198
Net Annual Growth	99	100	118	118	105	89	100	92	95	103	113
Inventory	2,048	2,673	3,129	3,376	3,430	3,620	2,887	3,062	3,254	3,407	3,494
Southeast											
Removals	169	158	161	147	185	286	289	163	129	127	135
Harvest	127	96	108	107	176	185	252	142	113	112	121
Net Growth	171	174	230	259	246	216	186	159	155	159	162
Inventory	5,588	6,220	7,248	7,542	8,157	7,423	6,620	5,697	5,703	5,911	6,192
Southcentral											
Removals	211	375	202	213	322	480	373	322	289	289	301
Harvest	157	227	213	184	323	342	356	307	279	285	303
Net Growth	203	285	379	453	348	395	413	308	299	295	287
Inventory	5,656	7,753	8,086	9,661	9,594	9,531	9,156	8,335	8,154	8,068	8,088
Pacific Southwest											
Removals	3	4	5	4	4	11	9	11	13	14	14
Harvest	2	3	3	3	24	12	19	23	27	31	31
Net Growth	11	15	24	19	46	54	42	44	40	32	34
Inventory	336	449	717	679	1,374	1,634	1,375	1,589	1,750	1,858	1,852
Douglas-fir subregion											
Removals	18	24	44	44	44	59	62	66	71	74	72
Harvest	18	22	37	34	57	71	82	88	94	99	97
Net Growth	75	98	124	145	154	111	134	127	123	120	113
Inventory	1,889	2,663	3,264	3,336	3,872	3,454	3,516	3,459	3,358	3,332	3,098
Ponderosa Pine subregion											
Removals	0	0	0	0	0	0	0	0	0	0	0
Harvest	0	0	0	0	0	0	0	0	0	0	0
Net Growth	0	0	0	0	0	0	0	0	0	0	0
Inventory	11	12	18	19	16	21	7	5	4	3	2
United States											
Removals	522	657	567	597	807	1,211	976	817	783	809	860
Harvest	421	434	487	472	998	1,120	1,156	1,036	1,037	1,106	1,200
Net Growth	688	828	1,068	1,220	1,129	1,098	1,086	938	921	920	922
Inventory	20,270	25,324	29,281	32,249	35,278	34,773	34,117	33,017	33,226	33,592	33,669

[1]*The Forest Industry timberlands in the Rocky Mountains are included with the Farmer and Other Private Timberlands for that region.*

[2]*Data for the Great Plains are included in the Rocky Mountains for the historical period and in the North Central subregion for the projection period.*

Note: Supply data for 1952, 1962, 1970, 1976, 1986, and 1991 are estimates of the trend level of harvests and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data shows the volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of Janaury 1. Inventory data shown under 1976, 1987, and 1991 are as of January 1 of following year.
Source: For historical data USDA Forest Service Powell, et al 1993.
Source: All projection data from TAMM LR 185.

Table 31.—Softwood removals, harvest, net annual growth, and growing stock inventory inventory (in million cubic feet) on Farmer and Other Private timberlands, 1952-1991 with projections to 2040.

Item	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
Northeast											
Removals	358	274	263	300	226	162	221	347	428	466	497
Harvest	338	258	244	278	296	258	323	550	676	708	733
Net Growth	433	539	510	623	441	457	468	463	460	452	446
Inventory	13,438	16,031	16,214	17,976	19,244	20,942	24,004	25,727	26,188	25,937	25,440
Northcentral[1]											
Removals	59	61	72	79	109	117	176	204	227	259	258
Harvest	62	63	70	74	119	125	219	269	297	329	320
Net Growth	128	152	170	196	250	240	222	223	224	227	235
Inventory	2,610	3,382	4,010	4,899	6,246	7,572	7,865	8,165	8,210	7,994	7,730
Southeast											
Removals	1,444	1,234	1,235	1,365	1,821	1,730	1,996	1,924	2,026	1,971	2,071
Harvest	1,414	1,189	1,157	1,247	1,640	1,456	1,814	1,751	1,848	1,810	1,914
Net Growth	1,349	1,567	1,882	2,130	1,656	1,435	1,603	1,712	1,744	1,744	1,746
Inventory	25,087	28,033	32,179	36,150	35,415	34,590	32,233	29,214	26,649	23,883	21,082
Southcentral											
Removals	606	787	1,117	1,278	1,569	1,548	2,154	2,124	1,874	2,039	2,601
Harvest	584	748	1,129	1,264	1,507	1,583	2,072	2,048	1,806	1,960	2,509
Net Growth	792	1,182	1,668	2,000	1,762	1,572	1,730	2,095	2,094	2,100	2,126
Inventory	11,273	16,128	23,646	28,760	31,555	29,801	29,015	28,209	30,060	31,963	31,038
Rocky Mountains[2]											
Removals	226	241	280	287	299	398	288	305	347	348	370
Harvest	207	219	256	262	305	146	231	256	305	313	352
Net Growth	293	341	388	388	440	529	485	444	411	413	433
Inventory	19,610	20,097	20,336	19,601	18,372	21,478	18,861	19,624	20,378	20,868	20,959
Pacific Southwest											
Removals	542	271	178	145	34	105	165	76	124	128	113
Harvest	468	230	163	136	35	59	188	94	177	173	146
Net Growth	178	192	211	197	238	205	259	241	224	199	188
Inventory	15,256	12,900	9,608	9,337	9,931	8,679	12,235	13,019	13,636	13,791	13,740
Douglas-fir subregion											
Removals	302	201	259	200	203	377	335	327	317	323	372
Harvest	317	207	245	195	232	427	385	374	361	369	432
Net Growth	265	308	358	340	409	443	374	366	374	390	397
Inventory	9,510	9,520	10,304	8,458	10,171	11,145	9,399	9,476	9,756	10,358	10,850
Ponderosa Pine subregion											
Removals	103	68	49	65	70	108	124	137	152	164	193
Harvest	100	67	48	60	65	61	85	99	133	170	227
Net Growth	109	136	148	121	122	132	164	159	164	159	144
Inventory	4,495	4,319	4,725	4,604	3,896	7,322	5,645	6,624	7,455	7,966	8,058
Alaska											
Removals	(1)	(1)	4	2	61	133	19	30	41	52	63
Harvest	(1)	(1)	5	2	54	123	20	32	43	55	66
Net Growth	1	2	2	3	21	19	29	38	48	57	67
Inventory	218	283	323	663	7,103	6,646	6,229	6,305	6,359	6,391	6,402
United States											
Removals	3,640	3,137	3,457	3,721	4,392	4,678	5,477	5,474	5,538	5,749	6,537
Harvest	3,490	2,981	3,317	3,518	4,253	4,238	5,336	5,473	5,645	5,887	6,699
Net Growth	3,548	4,419	5,337	5,998	5,339	5,033	5,335	5,741	5,743	5,741	5,782
Inventory	101,497	110,693	121,345	130,448	141,933	148,175	145,486	146,364	148,692	149,151	145,300

[1]*Data for the Great Plains are included in the Rocky Mountains for the historical period and in the North Central subregion for the projection period.*

[2]*The Forest Industry timberlands in the Rocky Mountains are included with the Farmer and Other Private Timberlands for that region.*

Note: See table 30.
1991 - 2040 data includes Indian lands, previously in Other Public.
Source: For historical data USDA Forest Service Powell, et al 1993.
Source: All projection data from TAMM LR 185.

Table 32.—Hardwood removals, harvest, net annual growth, and growing stock inventory inventory (in million cubic feet) on Farmer and Other Private timberlands, 1952-1991 with projections to 2040.

Item	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
Northeast											
Removals	424	503	591	623	630	472	813	885	967	1,030	1,133
Harvest	404	438	448	462	1,241	1,315	1,564	1,713	1,863	2,024	2,262
Net Growth	1,018	1,296	1,465	1,491	1,620	1,857	1,482	1,465	1,433	1,378	1,337
Inventory	32,669	39,863	44,751	49,457	58,505	66,086	70,572	76,338	80,088	82,749	84,476
Northcentral[1]											
Removals	629	661	797	793	932	875	1,148	1,203	1,235	1,253	1,303
Harvest	751	685	738	737	1,326	1,542	1,899	2,019	2,088	2,162	2,293
Net Growth	961	980	1,084	1,137	1,377	1,288	1,376	1,374	1,366	1,369	1,392
Inventory	24,385	29,009	31,821	35,636	42,884	48,881	51,526	52,800	53,716	54,523	55,506
Southeast											
Removals	817	861	843	801	1,096	1,049	1,509	1,820	1,890	1,830	1,805
Harvest	617	523	566	586	1,043	1,053	1,314	1,586	1,655	1,621	1,620
Net Growth	1,020	1,175	1,439	1,715	1,633	1,526	1,359	1,186	1,139	1,131	1,140
Inventory	32,316	36,288	40,583	46,478	51,487	52,594	50,279	46,221	38,843	31,485	24,853
Southcentral											
Removals	1,396	1,313	1,012	948	1,208	1,143	1,821	2,265	2,457	2,378	2,373
Harvest	937	730	848	713	1,212	1,201	1,739	2,165	2,371	2,350	2,392
Net Growth	1,424	1,459	1,845	2,117	1,800	2,116	2,482	2,287	2,074	1,907	1,832
Inventory	37,669	39,691	42,243	45,836	53,471	59,684	64,175	65,931	61,997	56,305	50,524
Rocky Mountains[2]											
Removals	30	24	21	20	18	20	3	5	7	10	11
Harvest	1	1	2	2	44	9	5	11	16	19	24
Net Growth	48	53	59	62	85	103	45	39	33	29	27
Inventory	2,354	2,514	2,701	2,784	3,495	4,278	2,424	2,694	2,915	3,082	3,201
Pacific Southwest											
Removals	4	7	10	8	1	3	27	30	33	34	34
Harvest	2	4	7	7	8	32	54	61	67	75	76
Net Growth	29	30	40	36	95	84	93	83	78	82	73
Inventory	998	1,050	1,562	1,598	3,352	2,992	3,932	4,203	4,372	4,537	4,583
Douglas-fir subregion											
Removals	8	29	22	47	7	30	95	110	126	133	140
Harvest	6	24	16	37	9	95	126	147	168	179	188
Net Growth	98	130	154	146	186	159	163	157	150	144	137
Inventory	3,135	3,902	4,634	3,728	5,099	5,143	5,403	5,763	5,970	6,028	6,013
Ponderosa Pine subregion											
Removals	0	0	0	0	0	0	2	2	2	2	2
Harvest	0	0	0	0	0	1	2	2	2	2	2
Net Growth	1	1	2	2	3	5	0	2	0	1	1
Inventory	62	70	77	79	102	207	78	88	78	79	80
Alaska											
Removals	(1)	(1)	(1)	(1)	(1)	3	3	3	3	3	3
Harvest	(1)	(1)	(1)	(1)	(1)	3	3	3	3	3	3
Net Growth	(1)	(1)	(1)	(1)	38	38	43	50	58	68	79
Inventory	39	82	102	121	2,312	2,312	2,684	3,121	3,635	4,238	4,947
United States											
Removals	3,308	3,398	3,296	3,240	3,892	3,595	5,420	6,322	6,719	6,671	6,805
Harvest	2,718	2,405	2,625	2,544	4,883	5,252	6,706	7,707	8,234	8,436	8,859
Net Growth	4,599	5,124	6,088	6,706	6,837	7,174	7,043	6,642	6,331	6,109	6,019
Inventory	133,627	152,469	168,474	185,717	220,707	242,177	251,073	257,160	251,614	243,026	234,183

[1]*Data for the Great Plains are included in the Rocky Mountains for the historical period and in the North Central subregion for the projection period.*

[2]*The Forest Industry timberlands in the Rocky Mountains are included with the Farmer and Other Private Timberlands for that region.*

Note: See table 31.

Source: For historical data USDA Forest Service Powell, et al 1993.

Source: All projection data from TAMM LR 185.

Table 33.—Softwood and hardwood timber harvest and growing stock inventory inventory (in million cubic feet) in the United States, by Region, 1952-1991 with projections to 2040.

Item	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
North[1]											
Softwoods											
Removals	622	528	583	692	725	723	867	950	1,015	1,066	1,096
Roundwood Supplies	596	501	549	636	908	940	1,210	1,424	1,510	1,530	1,534
Net Annual Growth	973	1,212	1,336	1,558	1,288	1,214	1,230	1,218	1,230	1,242	1,260
Inventory	27,053	33,661	38,817	43,850	47,618	50,977	54,011	56,896	59,312	60,555	62,033
Hardwoods											
Removals	1,279	1,391	1,722	1,801	1,982	2,029	2,410	2,556	2,702	2,811	3,000
Roundwood Supplies	1,381	1,329	1,465	1,502	3,190	3,684	4,249	4,555	4,831	5,128	5,574
Net Annual Growth	2,743	3,213	3,593	3,790	4,223	4,148	3,834	3,731	3,684	3,647	3,643
Inventory	76,695	94,627	106,867	119,158	142,420	156,142	167,862	179,406	188,276	195,780	202,343
South											
Softwoods											
Removals	3,122	2,823	3,674	4,437	5,740	5,840	6,689	6,812	7,532	8,352	8,932
Roundwood Supplies	3,036	2,707	3,527	4,251	5,317	5,283	6,268	6,389	7,082	7,891	8,477
Net Annual Growth	3,641	4,699	5,644	6,314	5,500	5,100	6,132	7,750	8,080	8,311	8,399
Inventory	60,462	75,087	89,156	101,208	105,613	102,927	99,426	106,259	115,350	119,179	117,523
Hardwoods											
Removals	2,731	2,832	2,344	2,241	2,958	3,086	4,131	4,710	4,905	4,760	4,750
Roundwood Supplies	1,933	1,662	1,840	1,707	2,931	2,914	3,788	4,329	4,549	4,501	4,569
Net Annual Growth	3,040	3,394	4,282	5,009	4,488	4,731	4,889	4,417	4,161	4,021	3,960
Inventory	88,008	98,985	109,271	122,165	139,027	147,667	151,619	150,977	142,996	133,902	125,951
Rocky Mountain											
Softwoods											
Removals	534	739	890	843	843	895	711	745	807	827	866
Roundwood Supplies	497	684	814	773	849	744	777	819	889	916	973
Net Annual Growth	1,101	1,258	1,455	1,594	1,956	1,985	1,926	1,993	1,954	2,043	2,067
Inventory	87,546	93,223	94,560	95,111	100,298	101,487	106,013	117,177	128,645	140,058	151,350
Hardwoods											
Removals	34	30	27	24	28	41	21	24	28	31	34
Roundwood Supplies	10	13	13	5	57	40	45	53	60	66	73
Net Annual Growth	87	99	119	139	169	168	104	98	98	93	91
Inventory	5,074	5,596	6,035	6,138	7,681	8,863	4,330	4,741	5,095	5,374	5,597
Pacific Coast											
Softwoods											
Removals	3,484	3,514	4,039	4,024	4,057	3,460	2,470	2,462	2,623	2,773	2,990
Roundwood Supplies	3,393	3,429	3,805	3,850	4,189	3,765	2,806	2,852	3,105	3,323	3,633
Net Annual Growth	2,021	2,445	2,905	3,034	3,777	3,642	3,792	3,861	4,154	4,352	4,380
Inventory	256,729	247,785	237,754	226,787	199,382	194,502	193,269	206,641	220,828	236,089	250,265
Hardwoods											
Removals	43	77	115	125	115	162	254	277	304	317	323
Roundwood Supplies	37	62	87	102	145	342	371	409	447	475	482
Net Annual Growth	304	389	485	486	681	604	622	601	555	537	517
Inventory	14,093	16,413	19,197	18,437	23,220	22,776	27,862	30,230	32,117	33,746	34,836
United States											
Softwoods											
Removals	7,763	7,604	9,187	9,996	11,366	10,917	10,738	10,969	11,979	13,017	13,883
Roundwood Supplies	7,522	7,321	8,695	9,510	11,263	10,731	11,060	11,484	12,585	13,660	14,617
Net Annual Growth	7,735	9,613	11,339	12,501	12,520	11,973	13,080	14,823	15,418	15,947	16,106
Inventory	431,790	449,756	460,287	466,956	452,911	449,893	452,719	486,973	524,136	555,881	581,170
Hardwoods											
Removals	4,087	4,330	4,208	4,192	5,082	5,318	6,814	7,566	7,938	7,918	8,107
Roundwood Supplies	3,361	3,066	3,405	3,316	6,323	6,979	8,453	9,346	9,888	10,170	10,697
Net Annual Growth	6,175	7,095	8,478	9,424	9,561	9,650	9,449	8,846	8,497	8,298	8,211
Inventory	183,870	215,621	241,370	265,898	312,348	335,448	351,674	365,354	368,484	368,802	368,727

[1] *Great Plains states included in North.*

Note: Supply data for 1952, 1962, 1970, 1976, 1986, and 1990 are estimates of the trend level of harvests and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data shows the volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1987, and 1990 are as of January 1 of following year.

Source: For historical data USDA Forest Service Powell, et al 1993.

Table 34.—Softwood and hardwood timber harvest and growing stock inventory (in million cubic feet) in the United States, by Ownership, 1952-1991 with projections to 2040.

Item	1952	1962	1970	1976	1986	1991	Projections 2000	2010	2020	2030	2040
National Forest											
Softwoods											
Removals	1,028	1,728	2,082	1,986	2,061	1,681	934	957	986	1,015	1,041
Roundwood Supplies	961	1,635	1,918	1,867	2,153	1,789	1,011	1,040	1,070	1,099	1,124
Net Annual Growth	1,664	1,999	2,367	2,468	2,783	2,747	2,779	2,924	3,061	3,185	3,225
Inventory	204,437	213,696	211,927	208,099	186,313	185,574	191,645	210,300	230,036	250,718	271,911
Hardwoods											
Removals	117	126	146	129	161	186	184	192	200	205	211
Roundwood Supplies	100	97	123	101	166	299	281	292	305	316	327
Net Annual Growth	396	508	573	658	617	544	532	497	491	499	507
Inventory	13,556	17,207	19,721	21,567	25,107	25,641	28,860	32,129	35,352	38,636	42,001
Other Public											
Softwoods											
Removals	429	568	750	851	858	616	705	729	741	752	755
Roundwood Supplies	403	562	702	822	814	769	890	939	953	964	969
Net Annual Growth	730	961	1,113	1,191	1,371	1,130	1,099	1,132	1,214	1,348	1,335
Inventory	55,184	55,720	57,521	59,039	57,255	50,002	54,088	58,069	62,450	67,800	73,683
Hardwoods											
Removals	141	150	199	225	222	326	234	235	236	233	231
Roundwood Supplies	122	130	170	199	276	309	310	310	312	312	312
Net Annual Growth	492	634	749	840	978	834	788	769	754	769	763
Inventory	16,417	20,621	23,894	26,365	31,256	32,857	37,623	43,047	48,292	53,549	58,874
Forest Industry											
Softwoods											
Removals	2,666	2,171	2,898	3,439	4,055	3,942	3,621	3,809	4,715	5,501	5,550
Roundwood Supplies	2,668	2,144	2,758	3,302	4,043	3,936	3,823	4,033	4,918	5,710	5,825
Net Annual Growth	1,793	2,234	2,523	2,844	3,027	3,063	3,867	5,026	5,400	5,673	5,764
Inventory	70,672	69,647	69,494	69,370	67,410	66,142	61,500	72,240	82,957	88,211	90,276
Hardwoods											
Removals	522	657	567	597	807	1,211	976	817	783	809	860
Roundwood Supplies	421	434	487	472	998	1,120	1,156	1,036	1,037	1,106	1,200
Net Annual Growth	688	828	1,068	1,220	1,129	1,098	1,086	938	921	920	922
Inventory	20,270	25,324	29,281	32,249	35,278	34,773	34,117	33,017	33,226	33,592	33,670
Farm & Other Private											
Softwoods											
Removals	3,640	3,137	3,457	3,721	4,392	4,678	5,477	5,474	5,538	5,749	6,537
Roundwood Supplies	3,490	2,981	3,317	3,518	4,253	4,238	5,336	5,473	5,645	5,887	6,699
Net Annual Growth	3,548	4,419	5,337	5,998	5,339	5,033	5,335	5,741	5,743	5,741	5,782
Inventory	101,497	110,693	121,345	130,448	141,933	148,175	145,486	146,364	148,692	149,151	145,300
Hardwoods											
Removals	3,308	3,398	3,926	3,240	3,892	3,595	5,420	6,322	6,719	8,671	6,805
Roundwood Supplies	2,718	2,405	2,625	2,544	4,883	5,252	6,706	7,707	8,234	8,436	8,859
Net Annual Growth	4,599	5,124	6,088	6,706	6,837	7,174	7,043	6,642	6,331	6,109	6,019
Inventory	133,627	152,469	168,474	185,717	220,707	242,177	251,073	257,160	251,614	243,026	234,183
United States											
Softwoods											
Removals	7,763	7,604	9,187	9,996	11,366	10,917	10,738	10,969	11,979	13,017	13,883
Roundwood Supplies	7,522	7,321	8,695	9,510	11,263	10,731	11,060	11,484	12,585	13,660	14,617
Net Annual Growth	7,735	9,613	11,339	12,501	12,520	11,973	13,080	14,823	15,418	15,947	16,106
Inventory	431,790	449,756	460,287	466,956	452,911	449,893	452,719	486,973	524,136	555,881	581,170
Hardwoods											
Removals	4,087	4,330	4,208	4,192	5,082	5,318	6,814	7,566	7,938	7,918	8,107
Roundwood Supplies	3,361	3,066	3,405	3,316	6,323	6,979	8,453	9,346	9,888	10,170	10,697
Net Annual Growth	6,175	7,095	8,478	9,424	9,561	9,650	9,449	8,846	8,497	8,298	8,211
Inventory	183,870	215,621	241,370	265,898	312,348	335,448	351,674	365,354	368,484	368,802	368,727

Note: Supply data for 1952, 1962, 1970, 1976, 1986, and 1990 are estimates of the trend level of harvests and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data shows the volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and the projection years are as of January 1. Inventory data shown under 1976, 1987, and 1990 are as of January 1 of following year.
Source: For historical data USDA Forest Service Powell, et al 1993.

of this increase comes from public lands, where growth exceeds projected cut by a substantial margin. For private lands alone, softwood inventories rise by 21 billion cubic feet or about 10% relative to 1991 levels. As harvesting proceeds, private softwood inventory becomes increasingly concentrated in the younger age groups, and, in many regions, management on regenerated acres becomes more intensive. Growth rises sharply as a result, increasing by nearly 43% between 1991 and 2040.

Within the aggregate private group, there are substantial differences in growth and inventory trends between industrial and nonindustrial owners. After 2000, industrial softwood inventories increase steadily to 2040. Growth rises by nearly 90%, as a result of extensive investment in timber management, while harvest grows by 40%. On nonindustrial lands, in contrast, inventory shows little trend over the projection, with growth and removals about balanced. Nonindustrial ownerships will account for the largest part of future losses in forest land to other uses, and are expected to implement only limited increases in timber management intensity.

Trends in the hardwood sector differ markedly from softwoods. Total hardwood inventory is projected to increase by less than 10% between 1991 and 2040, entirely because of expansion on public lands. Private hardwood inventories and growth decline, with the biggest reductions on nonindustrial ownerships and in the two Southern regions. These developments reflect the large projected increases in hardwood harvests, significant trends toward conversion of hardwood sites to softwood plantations on industrial lands in both the West and South, and little more than custodial management on the sites that are retained in hardwood types.

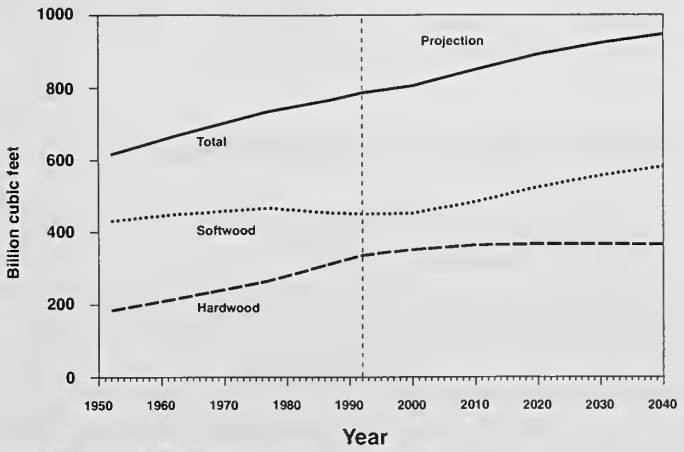

Figure 6.—U.S. inventory.

Regional shares of total softwood and hardwood harvest, derived from tables 33 and 34, are shown in the following tabulation.

	1991	2000	2040
	percent of U.S. harvest		
Region			
North	26	28	28
South	47	52	52
Rocky Mountains	4	4	4
Pacific Coast	23	16	16
Species			
Hardwood	39	43	42
Softwood	61	57	58

Nearly all of the near-term increase in harvest comes in the East. In the longer-term, the Pacific Coast region continues to lose share of harvest despite modest harvest increases in the Douglas-fir subregion. Finally, as a result of increased use in pulpwood, and to a lesser extent board products, the share of hardwoods in total harvest rises modestly during the 1990s and remains higher throughout the projection.

Developments in the inventories of three region-owner groups, the Douglas-fir forest industry, Southern forest industry and Southern nonindustrial, play particularly important roles in shaping future harvest and price behavior for softwoods.

Douglas-fir Forest Industry

The structure of the Douglas-fir region forest industry inventory sharply limits any compensatory harvest increase in response to declining public cut in the 1990s. Figure 7 shows the distribution of Douglas-fir industrial softwood inventory by age class for the years 1990, 2010, and 2030. In 1990, only a small portion of the inventory lies at or above the minimum merchantable age groups of 40-49 and 50-59 years. A significant harvest increment in the 1990s is not possible; and by the end of the 1990s, harvests are concentrated in those acres that just move above the minimum merchantability limits.[19] Over the en-

[19]*Minimum merchantable age varies by site quality and management intensity, being lower when site and management intensity are high. Because the inventory contains a mix of sites and management intensities, and owners are cutting just at the minimum merchantability limits in our projection, we see acreage distributed across both the 40-49 and 50-59 year groups in decades after 1990.*

suing years, however, the inventory becomes more evenly distributed across the classes from 0 to 59 years, and each decade increasing volumes of timber reach the minimum merchantability limits. This produces the rising inventory volume and harvest trends shown in table 29 after the year 2000, rising harvest that ultimately contributes to the stabilization of stumpage and product prices.

Southern Other Private

During the decade of the 1990s, Southern timber harvest is projected to rise sharply in response to harvest reductions in the West and higher prices for products and stumpage. Harvest growth slows in the period from 2000 to 2015, however, particularly on other private ownerships, causing regional stumpage prices and national product prices to continue to rise. Figure 8 shows the acreage distribution of Southern other private timberlands for 1990, 2010, and 2030. The 1990 inventory, rather than declining continuously from the youngest to the oldest group, drops in the 8-12 and 13-17 year classes, then rises to a peak in the 28-32 year group. This trough, termed an "age class gap", results from sharply reduced rates of planting and accelerated loss of Southern nonindustrial lands to non-forest uses in the 1970s and early 1980s. As this trough moves through the age classes over time, there is a temporary reduction in harvestable acres in successively older age classes. By 2000, the "gap" is just at the minimum limit of merchantability of about 20 years (for pulpwood). By 2010, there has been a sharp reduction in harvestable acreage in the primary sawtimber age groups (over

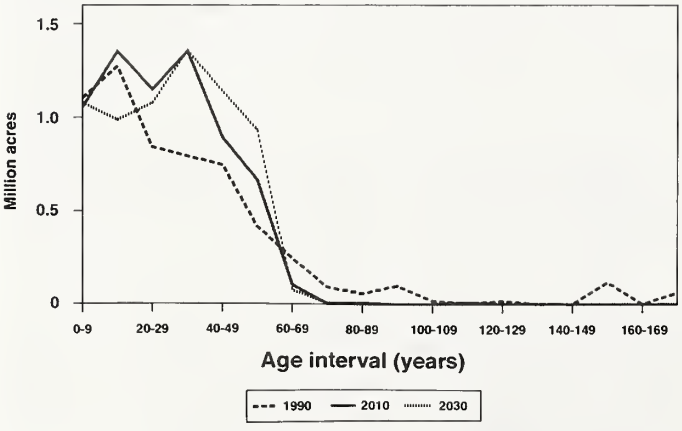

Figure 7.—Timberland area by age class, PNWW forest industry.

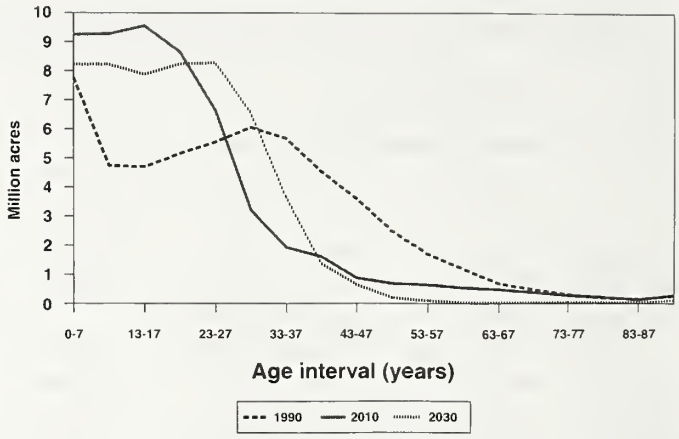

Figure 8.—Timberland area by age class, Southern Other Private.

25-30 years), restricting further harvest expansion. After 2010, the Southern other private inventory (like the PNWW forest industry inventory) is being harvested at ages very close to merchantability minimums, and removals show only modest increases.

Southern Industrial

The Southern industrial inventory does not include a "gap" as in the nonindustrial case; but, by the end of the 1990s, it contains only limited acreage in ages above merchantability minimums (fig. 9). This limits its ability to support expanded harvests during the 2000-2010 period to augment the restricted cuts from nonindustrial ownerships. (Southcentral industrial cut actually falls in this period.) In subsequent periods, however, the effects of extensive plantation establishment and intensification of management are realized. The acreage available for harvest at or just above merchantability limits expands dramatically and removals stabilize in the Southeast and expand sharply in the Southcentral.

PROJECTIONS OF CANADIAN HARVEST

Over the past two decades, concerns have emerged about the sustainability and broader environmental impacts of timber management on the vast areas of public forest lands in Canada. As in the case of public forest lands in the U.S., key issues include the adequacy of regeneration after harvest, the need for parks, wildlife habitat and broader purpose ecological reserves, and native land claims. The effect of

these concerns would be to reduce the annual allowable cut (AAC) levels set by the provinces to regulate harvested volumes.[20] This is, at present, a highly controversial prospect in Canada, and the extent and timing of any reductions are uncertain. While virtually all of Canada's major timber producing provinces are involved to some degree in such considerations, the debate can be illustrated in the case of British Columbia. A statement from the Provincial government, citing preliminary results of an ongoing timber supply review, notes that "...unless we change our approach [to forest management], the harvest could decline by 15 to 30% over the next 50 years" (Government of British Columbia, 1994). Similar percentage reductions have been suggested for other provinces.

As noted previously, the base projection assumes that public policies regulating management on both private and public forest lands remain fixed in the forms and structures observed in the early 1990s. Therefore, we have assumed that Canadian AACs continue through the projection period at their approximate 1990 levels. This presents immediate limits on harvest only for coastal British Columbia, which has been operating close to its AAC.

Harvest projections by provincial group are given in table 35 for softwood sawtimber and pulpwood. These projections show total Canadian softwood harvest rising slowly for the next several decades, with most of the increase coming as sawtimber in the eastern provinces. Pulpwood harvest is expected to decline in the next two decades, because higher levels of recycling in the United States reduces the competitiveness of Canadian newsprint producers. Sawtimber harvest levels for the British Columbia coast region are relatively stable (although there are near term declines), reflecting the proximity of this area's AAC limit.

[20]*The allowable annual cut (AAC) is used in Canada to specify the amount of timber that is permitted to be cut annually from an area over a specified period of time. The AAC is used to regulate the harvest level to ensure a long-term supply of timber.*

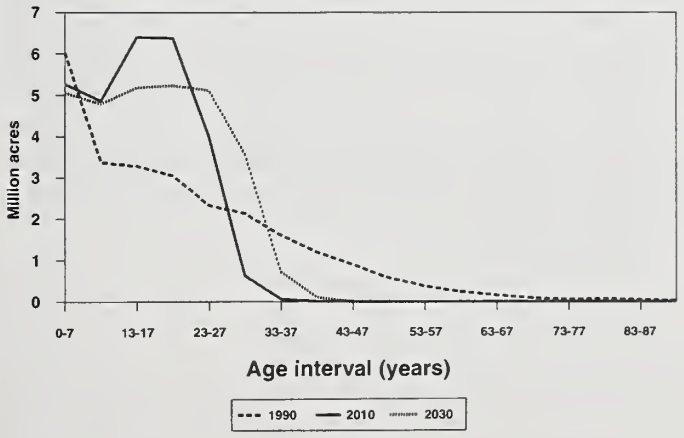

Figure 9.—Timberland area by age class, Southern Forest Industry.

Table 35.—Projections of Canandian softwood harvest (in million cubic feet).

	Sawtimber harvest quantities			Pulpwood harvest quantities		Total softwood harvest
	BC Coast	Interior provinces[1]	East[2]	West[3]	East	Total
1986	614	2,019	1,361	302	1,020	5,316
1990	517	2,157	1,360	233	920	5,187
2000	423	2,246	1,568	233	903	5,583
2010	476	2,275	1,801	265	941	5,967
2020	490	2,301	2,056	316	1,097	6,196
2030	505	2,239	1,910	385	1,291	6,221
2040	512	2,162	1,869	475	1,519	6,327

[1]*BC Interior; Alberta, Saskatchewan, Manitoba provinces.*

[2]*Ontario, Quebec, New Brunswick, Nova Soctia, Prince Edward Island, and Newfoundland provinces.*

[3]*BC coast + interior provinces.*

IMPLICATIONS OF THE BASE PROJECTION

From the national perspective, the base projection suggests that America's future forest resource will be comprised of two increasingly distinct and spatially separated components. Private ownerships, the largest element by land area, will:

- contain slightly more timber volume (of all species combined) in 2040 than they did in 1991,
- grow 12% faster,
- support a 48% larger total harvest, and
- include 7% (24 million) fewer acres resulting from losses to other land uses.

Achieving these productivity increases on a reduced land base will, however, entail a significant change in the structure of these forests.

1. Hardwood inventory, growth and land area will decline, both because of limited management and because of conversion of some areas to softwoods. Losses in hardwoods explain the imbalance between increases in growth and harvest in the aggregate of all species noted. In 2040, there still will be more hardwood inventory than there is softwood, but softwood inventory and growth will have risen in both relative and absolute terms. The softwood inventory will change as well, with plantations (often of genetically selected stock) replacing stands of natural origin.

2. On both industrial and nonindustrial lands, most of the inventory will be concentrated in ages near or below minimum merchantability limits. On industrial ownerships in both the West and South, these age classes will be arrayed in approximately equal areas from smallest to largest. Although there will be variation by region and species groups, private forests will be younger and, on average, smaller in diameter, and there will be no significant areas of private old-growth timber remaining.

3. Timber management will become more intensive, particularly on industrial ownerships. The intent of management intensification is generally to reduce delays in stand regeneration and increase rates of tree growth once stands are established. The effect is to reduce the area of stands on private lands in the earlier stages of successional development (grass-forb, shrub, and open sapling-pole-sawtimber) by accelerating site occupancy and hastening closure of the stand canopy (moving stands more quickly into the closed sapling-pole-sawtimber and larger stages).

Public ownerships, in contrast, will have experienced a lengthy period of reduced harvests and will contain:

- rising and aging inventories,
- rising absolute growth though a declining growth rate, and
- the only significant remaining areas of old-growth.

There will be variation across ownerships, just as in the private sector, and some groups of public lands (mostly non-federal) will more closely resemble the private industrial structure. The age class structures of public lands will be spread across a wide range and will not be approaching a uniform condition. Both hardwoods and softwoods will increase in volume, although only softwoods will experience rising growth rates. Management intensity on these lands may remain somewhere intermediate between that on industrial and nonindustrial private ownerships, depending on how the shift to ecosystem management on federal timberland evolves.

Given the geographic concentrations of public and private ownerships, both within and across regions in the U.S, lands of these two types will not be uniformly intermingled. The bulk of public forest land is in the West and, in both the West and East, concentrated largely in the mountainous and less accessible portions of the regions. Therefore, the two owner classes contain different mixtures of forest ecosystem types and site qualities.

The inventory trends described here will have important impacts on water quality and the timing and extent of water yields, wildlife populations and fisheries, recreation and amenity values, and the extent and quality of forested range available for domestic livestock. These concerns are addressed in detail in other parts of this Update. Here we offer only a few observations on terrestrial wildlife habitat impacts as they relate directly to the structure of the timber inventory.

The general timber age and size trends anticipated on private and public lands will bring changes in the types of wildlife habitat they provide. On private lands, habitat will shift to favor species that can utilize early and mid-successional stages of forest vegetation; on public lands, mid- to late successional habitat will become more abundant. The balance of these broad habitat groups will vary by region and the intensity of management practiced on private lands. With reduced harvests on public forests, processes of habitat fragmentation will be slowed somewhat on these lands. Trends toward further ownership fractionation of the nonindustrial private land base, however, suggest increased fragmentation of habitat in that ownership. Further, the growing and fairly marked differences between private and public lands do not suggest any reduction in habitat fragmentation at the broader regional or multi-ownership level. Islands of public ownership will become increasingly isolated and increasingly differentiated from surrounding lands.

The base projection envisions important shifts in the geographic and product concentration of the forest industry that will influence employment opportunities in, and the structure and viability of, regional and local economies. There is a clear pattern of movement of the solidwood processing sector from West to East as public harvest declines. Because little growth is expected in the western pulp and paper sector, the overall importance of the forest industries in western economies will decline. In the East, aggregate output of the forest industries will rise. There will be particularly rapid growth in softwood lumber processing, but overall the **mix** of output from the solidwood sector (lumber and panels) versus the pulp and paper sector will remain fairly stable. This portends some significant employment expansion opportunities in the East, even in traditional industries such as lumber.

The base projection suggests that the long-term position of the U.S. as a net importer of forest products will not change by 2040. Levels of both imports and exports vary little over the projection. The product composition of U.S. trade does change, but these shifts are largely offsetting. The most important changes involves a sharp rise in net softwood lumber imports (as western timber supplies decline), while the pulp and paper sector becomes a large net exporter (with increased use of recycled fiber and lower cost hardwoods).

CHAPTER 4. ALTERNATIVE FUTURES

The base projection gives one view of the future based on assumptions about determinants of timber demands and supplies described in chapter 2. As is true of all projections, the base case was strongly influenced by conditions in the forest products sector and general economy at the time it was made.[21] But there are many possible views of the future derived from divergent opinions about changes in the major determinants of supply and demand for both products and stumpage (including public harvests and other public policies, rates of recycling, developments in the general economy, etc.). Both individually and together, such changes can lead to projected trends in the forest sector that differ significantly from the base case. This chapter examines some of these alternative futures and their economic impacts on the forest sector and timber markets. The objective is to demonstrate both the sensitivity of the base projections to changes in input assumptions and to provide a basis for assessing the robustness of policy conclusions drawn from the base Assessment projections.

Thirteen alternative futures were examined. The following descriptions highlight key points in each.

1. **Lower Canadian Lumber Production.**—Canadian sawtimber harvest is limited to volumes at or below current levels in all provinces. Even in provinces where current allowable cuts would allow some increase in harvest, it is assumed that no increases will result from policy changes.

2. **Expanded Regulation of Private Timberlands.**—Two alternatives examine the potential impact of increased state and local regulation of private timberlands. The first deals with the effects of current (1990-91) regulations on private timber supply once these regulations are fully implemented. The second examines the impacts of additional regulations in the future—regulations now being debated but not adopted.

3. **Reduced Pine Plantations in the South.**—This scenario examines reduced rates of pine plantation establishment in the South, with more area retained in natural pine and oak-pine stands. By 2040 the projected area of plantations is reduced by 5.1 million acres or about 11% of the base case level.

4. **Higher Rates of Recycling.**—Future efforts to reduce waste by recycling waste paper are increased. By 2040, the waste paper utilization rate rises from the 45% level in the base to 60%.

5. **Alternative Macroeconomic Assumptions.**—The U.S. economy develops according to a scenario from the President's Council of Economic Advisors (CEA) showing, among other differences, slower GNP growth, lower housing starts, and higher expenditures on residential upkeep and alteration than the base case assumptions.

6. **Tree Planting Programs.**—We examine three alternative views of the future where tree planting on nonindustrial private ownerships is subsidized by Federal Government funding as a means to sequester atmospheric carbon. Two strategies focus on marginal crop and pasture lands suitable for conversion or afforestation to softwood plantations. The first assumes federal funding of $110 million per year for 10 years, distributed across regions so as to obtain the largest tonnage of carbon sequestered. The second strategy involves public subsidies sufficient to plant all acres of marginal crop and pasture land suitable for conversion to forest cover. A third approach concentrates exclusively on timberlands, aiming to accelerate management on all those areas that promise to return at least 4% on monies invested.

7. **Changes in National Forest Harvest.**—Timber harvests from the national forests are assumed to continue at their late 1980s levels in most regions, increasing in the Rockies and South. Harvest levels in this scenario are well above those in the base.

[21] *The base assessment projections were made in fall 1993. Most series had been revised through 1989, and some (especially the various macroeconomic variables) had been revised through 1992.*

8. **Increased Use of Wood for Energy.**—This alternative examines the impacts of increased use of wood for energy based on the Department of Energy's National Energy Strategy. Fuelwood demand rises by about 2.8 times over the base.

9. **Global Climate Change.**—One view of the impact of global warming on U.S. forests sees timber growth rise over time, because of increased rainfall and temperatures.

10. **Combined Environmental and Energy Policies.**—This run examines the net effect of a mixture of three policies aimed at environmental and energy issues much debated in recent years: (1) the higher wastepaper utilization rates from scenario 4 above; (2) increased use of wood for energy from scenario 8; and (3) tree planting subsidized by the $110 million funding per year for 10 years from scenario 6.

Table 36 summarizes the resource and market projections from the several alternatives. Results are displayed by region and category of impact.

LOWER CANADIAN LUMBER PRODUCTION

There has been some discussion in recent years of possible reductions in allowable cut levels on Crown lands in virtually all Canadian provinces (Government of British Columbia, 1994; Reed[22], Apsey and Reed, 1994). Reductions would result from a combination of land withdrawals for wildlife habitat, parks, and ecosystem preserves, and because of lagging regeneration on harvested lands. The extent of any restrictions is highly uncertain, as is the distribution of reductions between the solidwood and fiber products sectors. To obtain some preliminary idea of the potential impacts of such changes on U.S. markets, we examine a case in which harvest restrictions are limited to the solidwood sector and act to constrain output in the future to levels no higher than those observed in recent years.

In the base projection, softwood sawtimber harvest increased in Canada in response to rising lumber prices in the U.S. As shown in the following tabulation, Canadian harvests were projected to increase by 20% over the next three decades:

	Base	No increase alternative
	million cubic feet	
1990	4034	4034
2000	4237	4084
2020	4847	4089
2040	4543	3878

The restriction reduces total Canadian softwood lumber output by an average of 3.6 billion board feet per year between 2000 and 2040 relative to the base. Because Canadian domestic and non-U.S. export demands are insensitive to price in our projections, exports to the U.S. fall by a similar amount. Net U.S. consumption falls by an average of 0.8 billion board feet per year (relative to a total of about 52 billion board feet) as U.S. domestic output rises by 2.8 billion board feet per year. Softwood lumber prices in the U.S. are, on average, 4.8% higher than the base.[23]

EXPANDED REGULATION OF PRIVATE TIMBERLANDS

During the past decade, many states have expanded the scope of their regulation of forest practices on private lands. Common objectives of these changes have been the preservation of, or reduction of disturbances in, key habitat areas for an array of wildlife species, including reservation of riparian areas to ameliorate hydrologic and fish habitat impacts. There has been much debate about the economic impacts of these and any further state and local regulation. In a recent study Greene and Siegel (1994) obtained judgmental estimates of the timber supply impacts of current and potential future changes in public regulation of private forest practices from panels of forestry experts in various U.S. regions. The result of this process was a set of average percentage reductions in private timber "supply" by region associated with the two levels of regulation (current and potential future).

[22] *Personnel correspondence, Les Reed, 6/22/93, on file with the authors.*

[23] *Price increases of this magnitude would raise the cost of lumber used in a typical single-family house by about $160 in 2010 and about $300 in 2040.*

Table 36.—Simulated effects of selected futures on projected consumption, production, price and harvest, by region, by selected years 1990-2040.

Year	Base	Reduced Canadian harvest	State regulations 1	State regulations 2	Reduced pine plantation	Higher recycling	CEA demand projections	Molten and Richards tree planting	Tree planting on crop and pasture-land	Treatment opportunities on timberland	Climate change	Biofuels	Higher NF harvest	EPA policy run
							million board feet							
Softwood lumber consumption:														
1991	43,623	43,623	43,623	43,623	43,623	43,623	43,623	43,623	43,623	43,623	43,623	43,623	43,623	43,623
2000	46,416	46,146	46,423	46,459	46,390	46,442	46,065	46,408	46,952	46,898	46,957	46,911	46,925	46,861
2010	49,916	49,345	49,888	50,234	49,748	50,049	52,818	49,914	50,642	50,725	50,659	50,400	50,799	50,295
2020	55,244	54,257	55,158	55,747	54,818	55,506	57,637	55,483	56,408	56,293	56,350	55,588	56,184	55,539
2030	57,703	56,623	57,793	58,357	56,672	58,085	60,708	57,954	59,292	58,812	59,788	58,214	58,937	58,043
2040	58,993	57,897	59,080	59,692	57,988	59,506	64,791	59,188	60,765	60,149	61,804	59,492	60,298	59,352
Softwood lumber production:														
1991	35,317	35,317	35,317	35,317	35,317	35,317	35,317	35,317	35,317	35,317	35,317	35,317	35,317	35,317
2000	36,524	37,156	36,549	36,622	36,478	36,586	36,243	36,516	36,611	36,718	36,620	36,513	36,548	36,399
2010	38,595	40,883	38,530	39,172	38,266	38,890	41,006	38,591	38,768	39,168	38,802	38,297	39,119	38,134
2020	42,393	46,091	42,250	43,586	41,683	43,173	44,833	43,089	43,602	43,216	43,537	41,728	43,314	41,571
2030	46,135	49,510	46,162	47,692	43,849	47,025	48,223	46,882	47,969	46,878	48,902	44,926	47,269	44,619
2040	48,123	51,422	48,358	50,171	45,294	49,595	51,952	48,956	50,509	48,949	52,415	46,355	49,535	45,932
Softwood lumber imports:														
1991	11,276	11,276	11,276	11,276	11,276	11,276	11,276	11,276	11,276	11,276	11,276	11,276	11,276	11,276
2000	12,862	11,959	12,845	12,807	12,883	12,827	12,792	12,862	13,311	13,149	13,307	13,368	13,346	13,432
2010	14,291	11,432	14,327	14,032	14,451	14,129	14,782	14,294	14,844	14,527	14,827	15,072	14,651	15,131
2020	15,940	11,255	15,997	15,250	16,224	15,423	15,893	15,484	15,895	16,167	15,903	16,949	15,960	17,057
2030	14,657	10,202	14,720	13,754	15,912	14,149	15,574	14,161	14,412	15,023	13,975	16,376	14,757	16,514
2040	13,958	9,564	13,811	12,610	15,783	13,001	15,928	13,321	13,344	14,289	12,478	16,226	13,853	16,509
							million square feet							
Softwood plywood consumption:														
1991	17,916	17,916	17,916	17,916	17,916	17,916	17,916	17,916	17,916	17,916	17,916	17,916	17,916	17,916
2000	16,987	16,996	16,984	17,096	17,038	16,999	16,748	16,977	17,082	16,992	17,000	17,038	17,064	17,003
2010	15,893	15,827	15,907	16,073	15,887	15,943	16,390	15,901	16,058	15,935	15,984	15,925	16,130	15,982
2020	15,587	15,405	15,582	15,906	15,494	15,652	15,526	15,654	15,848	15,621	15,785	15,580	16,004	15,843
2030	15,356	14,950	15,429	15,942	14,952	15,569	14,700	15,574	15,808	15,527	15,851	15,186	15,858	15,683
2040	15,288	14,844	15,455	16,139	14,828	15,607	14,820	15,557	15,858	15,554	16,593	15,053	15,814	15,583
							1982 = 100							
All softwood lumber price index:														
1991	113.1	113.1	113.1	113.1	113.1	113.1	113.1	113.1	113.1	113.1	113.1	113.1	113.1	113.1
2000	139.2	143.1	139.1	138.5	139.4	138.7	141.8	139.3	138.6	139.2	138.6	139.4	139.1	140.9
2010	147.5	151.4	147.8	143.7	149.3	144.3	157.0	147.2	146.3	145.0	146.1	149.2	144.4	150.4
2020	159.5	167.8	160.0	154.3	163.4	156.7	162.6	157.6	155.8	154.9	156.7	163.1	157.6	163.4
2030	155.8	163.7	154.6	148.4	165.8	152.8	162.1	153.3	148.9	153.6	143.2	159.6	152.7	160.6
2040	164.2	170.0	162.2	156.8	172.3	158.6	170.0	160.8	155.1	161.3	144.2	167.8	162.0	170.3
All softwood plywood price index:														
1991	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3
2000	106.9	107.8	106.6	106.6	106.5	106.5	105.6	106.8	106.5	106.3	106.2	107.4	106.8	106.1
2010	113.0	114.0	112.6	112.1	113.9	112.4	124.5	112.4	112.2	112.2	111.8	113.6	110.6	111.7
2020	124.7	127.5	124.9	121.5	126.6	124.4	122.6	124.1	123.3	124.4	122.7	126.0	121.4	122.2
2030	125.8	131.6	126.2	122.5	131.6	124.2	125.9	124.4	123.1	125.1	120.6	127.4	123.1	124.8
2040	134.6	141.7	134.8	124.9	142.1	131.1	138.2	131.9	128.6	131.7	118.7	135.3	130.9	134.4

(continued)

Table 36.—(continued).

Year	Base	Reduced Canadian harvest	State regulations 1	State regulations 2	Reduced pine plantation	Higher recycling	CEA demand projections	Molten and Richards tree planting	Tree planting on crop and pasture-land	Treatment opportunities on timberland	Climate change	Biofuels	Higher NF harvest	EPA policy run
All hardwood lumber price index:														
1991	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2	127.2
2000	163.4	163.8	163.3	163.2	163.3	163.3	178.7	163.4	163.3	162.8	163.2	163.4	163.3	163.4
2010	188.4	189.3	188.4	187.6	188.6	188.2	206.2	188.4	188.2	186.9	188.0	188.9	187.9	189.0
2020	209.9	211.1	209.8	208.5	210.3	209.2	223.6	209.4	208.7	207.6	208.7	211.4	209.6	211.0
2030	224.5	225.6	223.8	222.5	225.8	223.3	236.2	224.1	222.3	221.4	221.2	227.3	223.6	227.0
2040	240.7	241.7	239.8	237.9	241.3	239.1	254.3	240.7	237.9	236.9	235.9	244.0	239.8	244.8
							1982 dollars per thousand board feet							
North softwood stumpage prices:														
1991	54.37	54.37	54.37	54.37	54.37	54.37	54.37	54.37	54.37	54.37	54.37	54.37	54.37	54.37
2000	82.54	83.46	82.15	81.10	82.64	81.86	84.04	82.51	81.99	76.48	79.64	82.73	82.21	82.86
2010	132.10	133.74	131.19	126.99	132.57	130.09	135.25	132.05	130.41	118.46	106.81	136.11	131.38	136.56
2020	160.36	162.86	159.16	149.88	161.34	157.05	161.72	159.64	157.06	140.77	119.18	171.83	160.44	172.28
2030	190.10	193.59	188.42	171.97	192.84	185.25	192.31	189.60	184.65	165.77	139.28	211.42	190.98	211.40
2040	211.67	215.48	210.38	185.74	214.79	205.24	214.82	211.05	203.59	183.70	147.54	240.78	213.76	239.88
South softwood stumpage prices:														
1991	144.56	144.56	144.56	144.56	144.56	144.56	144.56	144.56	144.56	144.56	144.56	144.56	144.56	144.56
2000	230.43	234.04	227.51	223.07	234.08	224.50	215.71	229.69	223.10	223.07	224.05	228.23	227.55	228.02
2010	275.25	295.83	275.22	261.01	294.95	265.44	290.68	266.65	260.29	266.29	263.12	278.28	265.52	272.00
2020	285.17	314.02	282.72	267.90	326.91	276.20	293.35	274.85	265.33	281.22	264.77	292.21	273.74	286.08
2030	277.09	308.80	273.87	244.54	331.90	263.63	287.28	262.87	250.99	266.86	231.59	285.96	263.47	278.19
2040	318.03	356.75	312.38	264.96	365.52	295.16	333.38	295.12	275.82	302.75	221.17	330.29	299.82	310.81
Rocky Mountains softwood stumpage prices:														
1991	59.16	59.16	59.16	59.16	59.16	59.16	59.16	59.16	59.16	59.16	59.16	59.16	59.16	59.16
2000	154.12	158.92	153.73	151.57	154.21	153.38	158.54	154.10	153.16	154.15	152.91	154.52	150.79	155.09
2010	150.02	168.96	144.54	138.74	152.36	143.88	176.26	149.79	143.88	143.72	139.30	152.08	96.62	153.35
2020	186.71	211.11	181.75	171.21	193.64	177.30	192.46	183.33	175.56	177.73	140.77	193.02	149.93	194.09
2030	185.59	214.91	179.63	164.76	200.24	175.96	196.69	182.83	168.97	177.23	103.75	195.79	146.08	197.98
2040	195.93	230.78	189.65	165.57	213.14	184.64	214.42	193.47	172.98	186.88	87.25	213.50	151.61	214.78
Pacific Coast softwood stumpage prices:														
1991	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.14	207.14
2000	234.48	240.08	233.76	231.57	234.10	233.95	260.07	234.22	233.17	234.08	230.82	238.74	231.69	235.67
2010	259.74	268.62	255.58	246.91	259.16	254.02	291.96	257.88	252.78	253.57	245.60	265.61	223.92	248.16
2020	284.58	301.19	279.86	260.61	290.88	273.83	326.62	277.87	268.64	274.51	257.02	289.93	249.22	236.35
2030	279.73	301.90	272.92	243.97	298.16	263.38	321.73	270.04	254.63	266.93	218.69	286.49	242.55	224.81
2040	277.77	303.55	269.78	229.47	304.62	259.11	325.02	266.57	247.25	264.00	186.21	281.22	240.09	221.83
North hardwood stumpage prices:														
1991	97.02	97.02	97.02	97.02	97.02	97.02	97.02	97.02	97.02	97.02	97.02	97.02	97.02	97.02
2000	120.81	120.91	120.47	119.48	120.77	120.35	123.82	120.80	120.45	111.75	119.59	121.34	120.50	121.37
2010	121.89	122.14	121.31	118.92	121.87	120.99	129.88	121.89	121.16	111.04	119.49	123.89	121.37	123.99
2020	131.37	131.78	130.72	126.50	131.40	130.13	136.32	131.26	130.26	119.53	127.55	136.61	130.86	136.58
2030	144.94	145.48	144.11	137.97	145.10	143.30	149.58	144.75	143.28	132.57	139.18	154.87	144.32	154.50
2040	161.12	161.80	160.23	152.47	161.29	159.18	164.58	160.88	158.76	148.33	153.53	176.14	160.46	175.80
South hardwood stumpage prices:														
1991	50.03	50.03	50.03	50.03	50.03	50.03	50.03	50.03	50.03	50.03	50.03	50.03	50.03	50.03
2000	64.52	64.75	64.17	63.95	63.91	64.09	67.11	64.59	64.05	63.34	64.01	64.46	64.20	64.47
2010	76.68	77.04	75.59	74.83	75.81	75.22	81.61	76.73	74.98	73.76	75.00	77.10	75.69	76.98
2020	94.48	95.00	92.00	90.37	92.87	91.19	95.56	94.19	89.32	88.28	89.80	97.30	92.25	96.29
2030	111.61	112.41	107.14	104.01	109.12	105.97	110.45	111.01	101.20	100.78	101.22	124.29	107.45	121.61
2040	130.74	131.85	123.53	117.72	126.73	122.06	126.71	129.68	113.27	113.73	112.39	157.44	123.87	156.46

(continued)

Table 36.—(continued).

Year	Base	Reduced Canadian harvest	State regulations 1	State regulations 2	Reduced pine plantation	Higher recycling	CEA demand projections	Molten and Richards tree planting	Tree planting on crop and pastureland	Treatment opportunities on timberland	Climate change	Biofuels	Higher NF harvest	EPA policy run
							million cubic feet							
North softwood harvest:														
1991	939	939	939	939	939	939	939	939	939	939	939	939	939	939
2000	1,210	1,211	1,205	1,190	1,210	1,186	1,217	1,210	1,207	1,220	1,219	1,264	1,216	1,266
2010	1,422	1,425	1,414	1,399	1,424	1,403	1,443	1,423	1,433	1,467	1,466	1,656	1,438	1,662
2020	1,509	1,514	1,492	1,457	1,510	1,481	1,510	1,508	1,523	1,568	1,576	1,918	1,539	1,913
2030	1,535	1,542	1,543	1,459	1,542	1,491	1,520	1,532	1,543	1,608	1,618	1,962	1,571	1,938
2040	1,540	1,548	1,561	1,474	1,548	1,497	1,504	1,537	1,537	1,628	1,646	1,866	1,590	1,847
South softwood harvest:														
1991	5,283	5,283	5,283	5,283	5,283	5,283	5,283	5,283	5,283	5,283	5,283	5,283	5,283	5,283
2000	6,268	6,308	6,055	5,757	6,266	5,737	5,960	6,269	6,042	6,081	6,037	6,063	6,081	6,069
2010	6,369	6,606	6,434	6,080	6,344	5,958	6,542	6,398	6,353	6,440	6,351	6,424	6,423	6,398
2020	7,065	7,425	7,001	6,604	6,931	6,540	7,206	7,223	7,348	7,275	7,265	7,233	7,004	7,480
2030	8,981	9,398	8,852	8,374	8,106	8,455	8,943	9,145	9,341	9,047	9,188	9,097	8,786	9,361
2040	8,492	8,794	8,348	7,880	8,003	7,979	8,225	8,668	9,004	8,608	8,925	8,742	8,371	8,841
Rocky Mountains softwood harvest:														
1991	996	996	996	996	996	996	996	996	996	996	996	996	996	996
2000	953	960	948	945	952	950	959	952	950	951	953	974	953	974
2010	902	927	891	883	907	890	938	902	889	890	895	968	949	968
2020	948	980	938	925	959	935	934	945	934	932	977	1,087	1,026	1,085
2030	1,015	1,046	1,001	989	1,038	1,004	1,029	1,012	984	1,007	1,030	1,213	1,089	1,212
2040	1,130	1,147	1,114	1,114	1,146	1,115	1,142	1,127	1,069	1,123	1,138	1,364	1,216	1,365
Pacific Coast softwood harvest:														
1991	3,498	3,498	3,498	3,498	3,498	3,498	3,498	3,498	3,498	3,498	3,498	3,498	3,498	3,498
2000	2,668	2,706	2,645	2,640	2,668	2,658	2,786	2,667	2,660	2,662	2,664	2,725	2,661	2,704
2010	2,731	2,789	2,680	2,660	2,713	2,672	2,886	2,704	2,673	2,674	2,696	2,869	2,789	2,810
2020	2,988	3,071	2,952	2,932	3,031	2,926	3,040	2,954	2,907	2,924	2,992	3,297	3,112	3,082
2030	3,194	3,230	3,154	3,169	3,282	3,094	3,172	3,154	3,106	3,148	3,230	3,619	3,364	3,417
2040	3,481	3,576	3,480	3,510	3,617	3,464	3,570	3,436	3,408	3,451	3,603	4,049	3,745	3,891
United States softwood harvest:														
1991	10,717	10,717	10,717	10,717	10,717	10,717	10,717	10,717	10,717	10,717	10,717	10,717	10,717	10,717
2000	11,099	11,186	10,852	10,532	11,096	10,531	10,921	11,099	10,858	10,914	10,874	11,025	10,910	11,012
2010	11,424	11,748	11,419	11,022	11,388	10,923	11,809	11,427	11,348	11,469	11,408	11,918	11,598	11,838
2020	12,510	12,989	12,384	11,918	12,432	11,883	12,690	12,629	12,712	12,699	12,810	13,535	12,681	13,561
2030	14,725	15,215	14,550	13,991	13,968	14,045	14,664	14,844	14,974	14,810	15,067	15,891	14,810	15,928
2040	14,643	15,065	14,503	13,977	14,315	14,054	14,440	14,768	15,018	14,810	15,313	16,022	14,923	15,944
United States softwood sawtimber harvest:														
1991	7,104	7,104	7,104	7,104	7,104	7,104	7,104	7,104	7,104	7,104	7,104	7,104	7,104	7,104
2000	7,055	7,146	7,059	7,075	7,051	7,065	6,968	7,053	7,073	7,084	7,069	7,058	7,063	7,046
2010	7,198	7,523	7,193	7,297	7,151	7,251	7,551	7,199	7,237	7,291	7,235	7,170	7,284	7,167
2020	7,632	8,138	7,614	7,821	7,519	7,756	7,947	7,739	7,829	7,760	7,806	7,573	7,774	7,622
2030	8,025	8,465	8,037	8,268	7,677	8,172	8,266	8,146	8,316	8,144	8,438	7,897	8,197	7,929
2040	8,101	8,518	8,144	8,403	7,685	8,325	8,579	8,230	8,460	8,229	8,740	7,907	8,305	7,923
United States softwood nonsawtimber harvest:														
1991	3,613	3,613	3,613	3,613	3,613	3,613	3,613	3,613	3,613	3,613	3,613	3,613	3,613	3,613
2000	4,044	4,040	3,794	3,457	4,045	3,466	3,953	4,045	3,785	3,829	3,804	3,967	3,847	3,967
2010	4,226	4,225	4,226	3,725	4,237	3,672	4,258	4,228	4,111	4,179	4,173	4,747	4,314	4,671
2020	4,878	4,851	4,770	4,098	4,913	4,126	4,743	4,889	4,883	4,939	5,003	5,963	4,907	5,939
2030	5,603	5,581	5,417	4,626	5,590	4,737	5,233	5,607	5,587	5,596	5,668	6,859	5,553	6,868
2040	6,542	6,547	6,359	5,574	6,629	5,730	5,861	6,538	6,557	6,581	6,573	8,114	6,618	8,020

(continued)

Table 36.—(continued).

Year	Base	Reduced Canadian harvest	State regulations 1	State regulations 2	Reduced pine plantation	Higher recycling	CEA demand projections	Molten and Richards tree planting	Tree planting on crop and pasture-land	Treatment opportunities on timberland	Climate change	Biofuels	Higher NF harvest	EPA policy run
North hardwood harvest:														
1991	3,684	3,684	3,684	3,684	3,684	3,684	3,684	3,684	3,684	3,684	3,684	3,684	3,684	3,684
2000	4,250	4,243	4,195	4,194	4,248	4,196	4,235	4,251	4,189	4,205	4,207	4,663	4,199	4,666
2010	4,553	4,554	4,520	4,454	4,551	4,483	4,582	4,553	4,519	4,558	4,570	5,908	4,521	5,906
2020	4,829	4,832	4,803	4,706	4,828	4,785	4,855	4,828	4,809	4,858	4,852	7,687	4,830	7,662
2030	5,137	5,145	5,122	4,981	5,141	5,065	5,228	5,134	5,084	5,151	5,149	9,217	5,162	9,170
2040	5,582	5,598	5,589	5,470	5,592	5,507	5,655	5,579	5,493	5,595	5,602	10,145	5,604	10,106
South hardwood harvest:														
1991	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914
2000	3,788	3,792	3,590	3,598	3,789	3,567	3,713	3,789	3,598	3,587	3,605	3,788	3,620	3,788
2010	4,329	4,333	4,172	4,163	4,331	4,086	4,289	4,330	4,121	4,129	4,161	4,637	4,192	4,626
2020	4,532	4,536	4,366	4,434	4,536	4,308	4,363	4,530	4,107	4,274	4,175	5,338	4,356	5,187
2030	4,497	4,502	4,340	4,473	4,507	4,370	4,275	4,492	4,083	4,264	4,107	5,753	4,354	5,659
2040	4,560	4,563	4,409	4,546	4,568	4,453	4,342	4,558	4,196	4,341	4,210	5,929	4,403	5,884
Rocky Mountains hardwood harvest:														
1991	43	43	43	43	43	43	43	43	43	43	43	43	43	43
2000	50	50	50	50	50	50	50	50	50	50	50	59	50	59
2010	60	60	60	60	60	60	60	60	60	60	60	91	60	91
2020	70	70	70	70	70	70	70	70	70	70	70	140	70	141
2030	84	84	83	83	84	83	83	84	83	83	83	197	83	198
2040	91	91	90	90	91	90	90	91	90	90	90	214	90	214
Pacific Coast hardwood harvest:														
1991	332	332	332	332	332	332	332	332	332	332	332	332	332	332
2000	361	361	361	361	361	361	359	361	361	361	361	407	361	407
2010	398	398	398	398	398	398	399	398	398	398	398	542	398	542
2020	436	436	436	436	436	436	434	436	436	436	436	744	436	744
2030	464	464	463	463	464	463	462	464	463	463	463	932	463	932
2040	471	471	470	470	471	470	472	471	470	470	470	951	470	951
United States hardwood harvest:														
1991	6,973	6,973	6,973	6,973	6,973	6,973	6,973	6,973	6,973	6,973	6,973	6,973	6,973	6,973
2000	8,449	8,446	8,195	8,204	8,448	8,173	8,357	8,451	8,198	8,203	8,223	8,917	8,230	8,920
2010	9,341	9,346	9,149	9,075	9,341	9,027	9,330	9,342	9,098	9,144	9,189	11,177	9,171	11,164
2020	9,867	9,875	9,675	9,646	9,870	9,599	9,722	9,864	9,422	9,638	9,532	13,909	9,692	13,734
2030	10,181	10,195	10,009	10,000	10,195	9,981	10,048	10,173	9,714	9,961	9,803	16,099	10,063	15,959
2040	10,704	10,723	10,558	10,576	10,722	10,519	10,559	10,698	10,250	10,496	10,372	17,238	10,567	17,156
United States hardwood sawtimber harvest:														
1991	2,429	2,429	2,429	2,429	2,429	2,429	2,429	2,429	2,429	2,429	2,429	2,429	2,429	2,429
2000	2,599	2,602	2,599	2,599	2,600	2,599	2,699	2,599	2,599	2,602	2,599	2,599	2,599	2,599
2010	2,761	2,770	2,763	2,759	2,765	2,762	2,907	2,761	2,762	2,764	2,762	2,763	2,759	2,764
2020	2,931	2,944	2,936	2,930	2,939	2,931	3,057	2,928	2,930	2,938	2,931	2,935	2,932	2,934
2030	3,028	3,042	3,031	3,029	3,046	3,028	3,131	3,026	3,027	3,040	3,021	3,022	3,028	3,025
2040	3,167	3,182	3,173	3,173	3,186	3,169	3,277	3,168	3,173	3,187	3,161	3,162	3,170	3,158
United States hardwood nonsawtimber harvest:														
1991	4,544	4,544	4,544	4,544	4,544	4,544	4,544	4,544	4,544	4,544	4,544	4,544	4,544	4,544
2000	5,850	5,844	5,596	5,605	5,848	5,574	5,658	5,852	5,599	5,601	5,624	6,318	5,631	6,321
2010	6,579	6,576	6,386	6,316	6,576	6,265	6,423	6,580	6,336	6,380	6,427	8,415	6,412	8,400
2020	6,954	6,950	6,758	6,734	6,949	6,686	6,684	6,955	6,511	6,719	6,601	10,975	6,760	10,818
2030	7,152	7,154	6,978	6,971	7,149	6,954	6,916	7,148	6,687	6,922	6,782	13,077	7,035	12,934
2040	7,537	7,541	7,385	7,403	7,537	7,351	7,281	7,530	7,076	7,309	7,211	14,076	7,397	13,998

(continued)

Table 36.—(continued).

Year	Base	Reduced Canadian harvest	State regulations 1	State regulations 2	Reduced pine plantation	Higher recycling	CEA demand projections	Molten and Richards tree planting	Tree planting on crop and pasture-land	Treatment opportunities on timberland	Climate change	Biofuels	Higher NF harvest	EPA policy run
North softwood private inventory:														
1991	39,296	39,296	39,296	39,296	39,296	39,296	39,296	39,296	39,296	39,296	39,296	39,296	39,296	39,296
2000	41,112	41,104	41,210	41,526	41,113	41,271	41,134	41,111	41,222	44,013	41,449	41,091	41,188	41,091
2010	41,959	41,921	42,135	43,092	41,960	42,307	41,843	41,957	42,270	46,162	42,672	41,070	41,961	41,056
2020	42,028	41,946	42,267	44,278	42,010	42,566	41,787	42,034	42,553	47,263	43,218	39,657	41,830	39,608
2030	41,518	41,371	41,876	45,510	41,456	42,428	41,375	41,538	42,409	47,684	43,409	37,573	41,120	37,671
2040	40,918	40,693	41,150	46,920	40,785	42,125	40,996	40,953	42,337	47,870	43,753	35,972	40,207	36,205
South softwood private inventory:														
1991	89,971	89,971	89,971	89,971	89,971	89,971	89,971	89,971	89,971	89,971	89,971	89,971	89,971	89,971
2000	85,570	85,455	86,711	88,321	85,537	87,748	87,592	85,679	88,394	89,266	87,401	86,605	86,774	86,723
2010	92,398	91,007	94,402	101,804	85,616	99,433	95,077	95,819	101,236	99,797	97,555	93,723	94,441	97,390
2020	101,246	96,755	102,990	118,516	89,383	112,602	101,390	111,235	119,562	110,590	109,591	100,814	103,661	110,802
2030	104,264	96,439	106,409	131,309	90,718	119,111	104,045	116,010	131,709	115,529	116,362	102,305	107,979	112,680
2040	101,524	92,429	104,822	140,127	88,558	119,921	102,472	115,534	135,890	114,104	118,560	98,347	106,531	110,360
Rocky Mountains softwood private inventory:														
1991	18,192	18,192	18,192	18,192	18,192	18,192	18,192	18,192	18,192	18,192	18,192	18,192	18,192	18,192
2000	18,862	18,839	18,894	19,062	18,863	18,878	18,815	18,862	18,877	18,871	18,918	18,831	18,872	18,831
2010	19,607	19,440	19,702	20,187	19,606	19,667	19,360	19,611	19,670	19,652	19,931	19,426	20,083	19,431
2020	20,283	19,767	20,507	21,359	20,202	20,474	19,734	20,313	20,541	20,465	20,871	19,764	21,788	19,723
2030	20,729	19,839	21,106	22,636	20,487	21,119	20,108	20,817	21,235	21,079	21,613	19,651	23,031	19,617
2040	20,805	19,544	21,317	23,974	20,345	21,354	19,999	20,938	21,707	21,295	22,479	18,907	23,792	18,898
Pacific Coast softwood private inventory:														
1991	55,040	55,040	55,040	55,040	55,040	55,040	55,040	55,040	55,040	55,040	55,040	55,040	55,040	55,040
2000	55,208	55,130	55,273	55,771	55,225	55,250	54,587	55,215	55,556	55,281	55,722	54,243	55,253	54,244
2010	58,491	57,795	58,716	60,462	58,551	58,709	56,356	58,555	59,479	58,800	60,296	55,678	59,627	55,989
2020	61,506	59,671	62,031	66,292	61,436	62,341	57,104	61,948	63,875	62,482	65,757	55,934	64,977	58,385
2030	64,339	61,125	65,230	73,250	63,439	66,094	58,247	65,363	68,750	66,156	72,062	55,866	69,847	60,685
2040	65,614	61,321	66,919	79,716	63,340	68,381	59,341	67,256	72,498	68,212	78,107	56,021	72,705	61,583
Total softwood private inventory:														
1991	202,499	202,499	202,499	202,499	202,499	202,499	202,499	202,499	202,499	202,499	202,499	202,499	202,499	202,499
2000	200,752	200,528	202,088	204,680	200,738	203,147	202,128	200,867	204,049	207,431	203,490	200,770	202,087	200,889
2010	212,455	210,163	214,955	225,545	205,733	220,116	212,636	215,942	222,655	224,411	220,454	209,897	216,112	213,866
2020	225,063	218,139	227,795	250,445	213,031	237,983	220,015	235,530	246,531	240,800	239,437	216,169	232,256	228,518
2030	230,850	218,774	234,621	272,705	216,100	248,752	223,775	243,728	264,103	250,448	253,446	215,395	241,977	230,653
2040	228,861	213,987	234,208	290,737	213,028	251,781	222,808	244,681	272,432	251,481	262,899	209,247	243,235	227,046
North hardwood private inventory:														
1991	126,475	126,475	126,475	126,475	126,475	126,475	126,475	126,475	126,475	126,475	126,475	126,475	126,475	126,475
2000	135,539	135,532	135,810	136,704	135,544	135,908	135,573	135,535	135,794	146,183	136,624	135,001	135,784	135,005
2010	143,085	143,076	143,706	146,471	143,102	143,990	142,956	143,074	143,772	159,171	145,922	140,844	143,547	140,794
2020	148,092	148,065	148,853	154,791	148,118	149,497	147,587	148,083	149,075	169,065	153,255	141,590	148,576	141,575
2030	151,717	151,616	152,670	162,935	151,706	153,677	150,686	151,720	153,108	177,342	160,129	138,337	152,188	138,680
2040	154,385	154,170	155,313	170,879	154,300	156,816	152,606	154,414	156,534	184,561	167,004	131,841	154,648	132,485
South hardwood private inventory:														
1991	124,573	124,573	124,573	124,573	124,573	124,573	124,573	124,573	124,573	124,573	124,573	124,573	124,573	124,573
2000	130,230	130,221	131,483	132,110	132,595	131,691	130,815	130,270	131,747	134,323	131,930	130,810	131,410	130,853
2010	126,171	126,138	129,873	131,799	129,821	130,820	127,199	126,483	131,408	135,117	131,307	126,240	129,397	126,616
2020	114,683	114,578	120,712	123,975	119,593	122,317	116,734	115,653	126,410	128,881	125,000	111,471	119,990	113,251
2030	101,772	101,511	109,698	114,548	107,725	111,778	106,115	103,138	120,822	120,838	119,408	91,199	109,039	94,476
2040	89,740	89,533	99,366	106,711	96,827	101,193	96,622	91,622	115,741	112,985	115,450	71,567	98,748	75,179

(continued)

Table 36.—(continued).

Year	Base	Reduced Canadian harvest	State regulations 1	State regulations 2	Reduced pine plantation	Higher recycling	CEA demand projections	Molten and Richards tree planting	Tree planting on crop and pasture-land	Treatment opportunities on timberland	Climate change	Biofuels	Higher NF harvest	EPA policy run
Rocky Mountains hardwood private inventory:														
1991	2,105	2,105	2,105	2,105	2,105	2,105	2,105	2,105	2,105	2,105	2,105	2,105	2,105	2,105
2000	2,424	2,424	2,426	2,442	2,424	2,424	2,423	2,424	2,424	2,424	2,437	2,418	2,424	2,418
2010	2,694	2,691	2,696	2,736	2,694	2,696	2,689	2,694	2,696	2,696	2,727	2,683	2,702	2,684
2020	2,881	2,873	2,920	2,951	2,881	2,887	2,871	2,883	2,920	2,918	2,971	2,850	2,930	2,849
2030	3,049	3,035	3,091	3,150	3,046	3,058	3,038	3,050	3,091	3,089	3,157	2,893	3,105	2,892
2040	3,171	3,152	3,214	3,310	3,165	3,184	3,159	3,173	3,216	3,211	3,303	2,841	3,234	2,838
Pacific Coast hardwood private inventory:														
1991	13,582	13,582	13,582	13,582	13,582	13,582	13,582	13,582	13,582	13,582	13,582	13,582	13,582	13,582
2000	14,310	14,309	14,315	14,414	14,311	14,314	14,289	14,311	14,353	14,328	14,412	14,126	14,314	14,127
2010	15,101	15,082	15,115	15,430	15,106	15,114	15,023	15,106	15,208	15,145	15,426	14,305	15,142	14,704
2020	15,517	15,462	15,544	16,207	15,514	15,555	15,336	15,535	15,727	15,601	16,175	13,770	15,628	14,151
2030	15,807	15,653	15,859	17,018	15,731	15,892	15,499	15,851	16,176	15,948	16,916	12,156	16,006	12,527
2040	15,588	15,386	15,666	17,408	15,458	15,738	15,275	15,665	16,169	15,789	17,302	9,420	15,868	9,669
Total hardwood private inventory:														
1991	266,735	266,735	266,735	266,735	266,735	266,735	266,735	266,735	266,735	266,735	266,735	266,735	266,735	266,735
2000	282,503	282,486	284,034	285,670	284,874	284,337	283,100	282,540	284,318	297,258	285,403	282,355	283,932	282,403
2010	287,051	286,987	291,390	296,436	290,723	292,620	287,867	287,357	293,084	312,129	295,382	284,072	290,788	284,798
2020	281,173	280,978	288,029	297,924	286,106	290,256	282,528	282,154	294,132	316,465	297,401	269,681	287,124	271,826
2030	272,345	271,815	281,318	297,651	278,208	284,405	275,338	273,759	293,197	317,217	299,610	244,585	280,338	248,575
2040	262,884	262,241	273,559	298,308	269,750	276,931	267,662	264,874	291,660	316,546	303,059	215,669	272,498	220,171

In our analysis of these scenarios, we first adjusted Greene and Siegel's percentages to reflect our judgement regarding the degree to which existing regulations had already been implemented, and, therefore, their impact already reflected in the stumpage supply relations. This adjustment is summarized table 37. We implemented these scenarios by multiplying both the sawtimber and pulpwood stumpage supply functions by (one minus) the appropriate fixed regional percentage.

The results run counter to intuition because of substitution of fiber sources in the pulp sector. In the potential future case, for example, reduced private supply lowers U.S. average annual softwood growing stock removals by some 4.7% relative to the base scenario. The largest impact is on pulpwood harvest, however, with a substantial shifting of pulp fiber demand to non-roundwood (residues) and non-wood (recycled fiber) sources. This leads to large supply shifts for the South. Changes occur very rapidly (softwood non-sawtimber harvest falls by 15% by 2000) and free enough additional inventory to allow sawtimber harvest to actually rise relative to the base. Expanded inventories and private supply lead to reduced sawtimber stumpage prices in all regions.

REDUCED RATES OF PINE PLANTATION ESTABLISHMENT IN THE SOUTH

The levels of tree planting on private timberland assumed in the base may not materialize in the South. An alternative was developed that reduced the rate of timberland conversion to pine plantations. Conversion represents the establishment of pine plantations following harvest of other softwood or hardwood forest types. Total timberland area did not change under this scenario; acres not converted to plantations were regenerated in their previous type. The plantation reduction was formulated by holding the projected rate of conversion in the decade 1990 to 2000 to the rate observed in the previous decade (1980 to 1990). The observed conversions were calculated with FIA inventory data. After the year 2000, the rate of acres converted to plantations returned to the base assumptions.

Table 37.—Estimated impacts of state and local regulations on private timber supply.

Region	Original estimates				Adjusted estimates			
	Current		Future		Current		Future	
	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood
North	-1	-3	-13	-9	0	-2	-12	-8
South	-3	-3	-15	-16	-2	-2	-14	-15
Rockies	-2	-3	-3	-4	0	-3	0	-34
Pacific Coast	-7	-12	-7	-16	0	-1	0	-14

Most reduced planting occurs in the South Central region, where base projections called for a 8.49-million-acre increase in plantations between 1990 and 2000, doubling the 9.7 million plantation acres in 1990. This alternative limits the increase to 4.11 million acres, for a total of 13.9 million plantation acres by 2000. The projected base trend in the Southeast was a more modest increase from 13.3 to 18.0 million acres, a change of 4.7 million acres. The increase here was reduced by 721 thousand acres, yielding a 2040 total of 17.3 million. In sum, Southern plantation acres were reduced by 9% by 1995, 14% by the year 2000; and as shown below, by 2040 the difference was 11%.

Total Southern Pine Plantation Areas

Year	Base	Alternative
	million acres	
2000	36.192	31.097
2010	40.925	35.830
2020	44.005	38.910
2030	45.326	40.231
2040	45.237	40.142

As might be expected, the impacts of reducing plantation establishment in the South are slow to develop, given the time required for stands to mature and enter the available timber inventory. Because these plantations are projected to produce relatively high rates of softwood growth per acre, in the long run, this alternative has the greatest impact on softwood lumber prices, because it reduces available inventories and consequently timber harvest in the South (timber harvests are 6% lower by 2040).

This scenario also stimulates a sharp rise in softwood lumber imports from Canada as increased production there offsets reductions in the U.S. South, particularly true for the period after 2010. Plywood consumption falls because most of this industry is in the South and is adversely affected by higher stumpage prices and lower softwood harvest. Unlike lumber, there are few alternative production sources for plywood and increased plywood price reduces consumption (plywood prices are 5.6% higher by 2040).

HIGHER RATES OF RECYCLING

This scenario examines the impacts of further increases in the use of wastepaper as raw material for paper and board production. In Assessment projections before 1988, it was generally assumed that wastepaper utilization rates would remain relatively constant at around 20%. Little change was expected because chip and pulpwood prices were projected to experience only modest growth (no growth was expected for hardwood pulpwood and chip prices in some regions). Projections for the 1989 Assessment abandoned this earlier view in recognition of growing national concerns about waste management. Utilization projections in the current Update rise still more rapidly reflecting major recent gains in actual levels of utilization and marked revisions in projections of future relative fiber costs. Ince (1993) discusses the technical basis for continued expansion in the utilization of recycled fibers and provides the motivation for this alternative.

The following tabulation gives recent historical rates of waste paper utilization[24] and projections from the current Update and past Assessments. It illustrates how substantially perceptions of prospects for future increases have changed over the past 6 years. The increased recycling scenario calls for utilization rates of about 60% beginning in 2020.

Wastepaper Utilization Rates

	Actual	1989 base	1993 base	Increased recycling
1986	24.7%			
1991	29.2%			
1993	33.0%[1]			
2000		21%	37.5%	45.3%
2010		22%	41.2%	56.5%
2020		25%	42.5%	60.6%
2030		27%	43.7%	60.8%
2040		28%	45.4%	59.5%

[1] *"Actual" percentage for 1993 is an estimate.*

Results of this scenario, as shown in table 36, are generally higher U.S. lumber production, lower imports from Canada, and lower stumpage prices especially in the South. The effect of greater use of recycled fiber is to lower nonsawtimber demand and aggregate growing stock removals for both softwood and hardwood in all regions. Particularly large pulpwood harvest reductions occur in Eastern softwoods, because the largest share of U.S. pulpwood harvest occurs in the East. Over time, this yields some expansion in timber inventories, reduces softwood sawtimber stumpage prices, raises sawtimber demand for lumber and plywood, and allows an expansion in softwood sawtimber harvest. Given this chain of interactions, and recognizing that all elements of private timber management intensity are fixed in the scenario at their base levels or trends, high recycling could have some potential to compensate for other policies that reduce timber supply.

[24] *Wastepaper utilization rate is the ratio of recovered waste paper used in domestic paper and board mills to domestic production of paper and board. See chapter 2 for further discussion.*

Higher rates of wastepaper utilization result in a 4.1% reduction in total demand for forest products by 2040, pulpwood falling by 12.3%. Some of the savings in wood that would have been used as pulp are diverted to the manufacture of other products, especially lumber. United States softwood lumber consumption rises 0.9%, imports of softwood lumber from Canada drop by 6.9%, and United States softwood lumber production rises by 3.1%. Consumption by sawtimber and pulpwood categories is shown in the following tabulation.

	Saw logs		Pulpwood	
Year	Base	Increased recycling	Base	Increased recycling
	billion cubic feet			
1991	7.1	7.1	3.6	3.6
2000	7.0	7.1	4.0	3.5
2020	7.6	7.8	4.9	4.1
2040	8.1	8.3	6.5	5.7

ALTERNATIVE MACROECONOMIC ASSUMPTIONS

The macroeconomic outlook underlying the base projection was derived from forecasts by Wharton Econometric Forecasting Associates in 1991 (WEFA, 1991). However, there are many views on the likely future development of the U.S. economy. To explore this variation we used an alternative macro-forecast developed by the Council of Economic Advisors (CEA) in early 1994. Comparisons of GNP, total housing starts and expenditures on residential upkeep and alteration from the two forecasts are shown in table 38. While the CEA projection does involve lower levels of GNP growth and new housing activity, it has substantially higher expenditures on residential upkeep and alteration and non-residential construction (not shown). As a result, the projections of the forest sector in table 37 show mixed changes across industries. Because paper and paperboard are so widely used in all sectors of the economy, demand is highly sensitive to changes in GNP. Thus projected nonsawtimber harvests are 10% lower than the base for softwoods by 2040 and 2% lower for hardwoods. Sawtimber harvest, lumber and plywood produc-

Table 38.—Alternative (CEA) Economic Assumptions.

Year	GNP		Number of households		Residential expenditures		Housing starts	
	RPA1	CEA2	RPA	CEA	RPA	CEA	RPA	CEA
	billion 1982 dollars		*millions*		*million 1982 dollars*		*thousands*	
1992	4,304	4,197	95	96	84,459	70,066	1,236	1,199
2000	5,383	5,147	108	105	96,401	95,922	1,384	1,400
2020	9,166	7,376	139	129	124,068	143,938	1,549	1,514
2040	15,627	9,881	161	149	143,869	191,738	1,252	1,175

[1]*RPA refers to macro assumptions used in the 1993 Assessment update.*

[2]*CEA refers to marcro assumptions made by the Council of Economic Advisors.*

tion and solidwood prices, in contrast, are all higher than the base. This results from the higher levels of residential upkeep and alteration and non-residential construction expenditures that more than compensate for lower solidwood use in new housing construction, manufacturing and shipping.

TREE PLANTING PROGRAMS

We examine three scenarios of publicly subsidized tree planting programs providing incentives to nonindustrial private landowners. The first two involve conversion of crop and pasture land to forest cover, with the objectives of reducing soil losses, increasing timber supply and sequestering atmospheric carbon. The third focuses only on nonindustrial lands already in forest cover, attempting to increase their growth and timber yields both to augment timber supply and sequester additional atmospheric carbon. Differences between these scenarios is a function of the number, timing, type and location of acres planted, although all three focus most of their efforts in the South. In general, these programs augment timber supply, increasing forest inventories and eventually reducing stumpage prices and increasing harvests.

The first scenario is based on work by Moulton and Richards (1990) who considered regional differences in the cost-effectiveness of forest plantations on marginal crop and pasture land to sequester carbon. Marginal crop and pasture land were defined for the contiguous United States based on soil erosion rates, soil type, and U.S. Soil Conservation Service land capability class. Enrollment schedules for these lands were determined by estimating the annual cost per unit of carbon sequestered and arranging the land units in ascending order of cost. With program funding of $110 million per year for 10 years, Moulton and Richards (1990) estimated the least cost carbon sequestration strategy would involve enrollment only of those available acres in Oklahoma and Texas. Some 5.8 million acres were involved, representing a 5% increase in timberland acres relative to 1992 timberland area estimates in the South Central region (Powell and others 1993). All acres would be planted with loblolly pine.

The second and third scenarios were derived from work by American Forests that examined increases in forest cover as part of mitigation efforts to slow the buildup of greenhouse gases in the atmosphere and to adapt to climate change (Sampson and Hair 1992). In the second, 23.4 million acres of marginal crop and pasture land in private ownership were identified as being suitable for conversion to softwoods forests (Sampson and Hair 1992). This included 2.72 million acres in the North, 19.73 million acres in the South and 0.95 million acres in the Pacific Coast region. These acres were added to softwood timber types spread over a 25-year period in the South and 50-year time period elsewhere.

The third alternative focuses only on those timberlands with opportunities for management intensification that promise a real rate of return of at least 4% on the monies invested (reckoning only the timber values obtained). Most of the opportunities involve either some type of regeneration (of poorly stocked stands) or stocking control (including commercial and noncommercial thinning). In general these opportunities increase net growth by 14%, 21%, 9%, 2%, and 1% in the Northeast, Northcentral, Southeast, Southcentral, and Pacific Northwest Westside, respectively.

Results of these scenarios are characteristic of tree planting programs generally. Prospective changes are greatest in the longer term as the planted acres mature and become part of the available timber inventory. As a consequence, tree planting is not effective in reducing near term price increases, but can have major impacts on long term levels. Softwood inventory and harvest projections increase under each scenario, while stumpage price projections decline relative to the base. By 2040, U.S. softwood inventory levels are 6.9%, 9.9%, and 19.0% higher, respectively, than under the base case, while hardwood inventories are 0.7%, 20.4%, and 10.9% higher, respectively. The greatest increases occur in the South (SC, SE regions), with privately owned softwood growing stock inventories projected to increase by as much as 46.0 billion cubic feet between 1991 and 2040 (table 36). Reduction in U.S. stumpage prices affects lumber trade between the United States and Canada. As U.S. stumpage prices decline, United States forest products become more competitive, thereby leading to a slight decline in Canadian lumber imports to the United States after 2010 (table 36).

While the first scenario is a relatively small planting program ($1.1 billion over 10 years), it still reduces Southern stumpage prices 7% by 2040. This affects individual private landowners who realize a reduction in wealth because of a public program. By 2020, harvest under the tree planting scenarios exceed those of the base case. Harvest increases are greatest in the South, where softwood harvest is projected to rise from 5,283 million cubic feet to 9,004 million cubic feet between 1991 and 2040 (table 36) for the second scenario.

IMPACTS OF GLOBAL CLIMATE CHANGE

This scenario examines the forest sector effects of global climate change resulting from increased atmospheric carbon dioxide. The analysis is based on work by Joyce (in press), who presents details of the derivation of the various inputs. It is assumed that atmospheric concentrations of carbon dioxide will double by the year 2065. Joyce's analysis indicates that this will result in gains in timber productivity because of an increase in available carbon coupled with an increase in rainfall and temperature. The increase in rainfall and temperature act to raise nitrogen availability and lengthen the growing season. The total growth increments (over the 75-year period from 1990 through 2065) are estimated to be 14.8%, 8.5%, 18.4%, and 12.5% in the North, South, Rockies, and Pacific Coast states, respectively.

Changes in growth were implemented in the projection by multiplying the base yield functions for each region and owner group by (one plus) the appropriate percentage gain as derived from Joyce. It is assumed that the growth increments are accompanied by increasing site carrying capacity, so that gains from growth are not offset by equivalent losses to mortality.

While the changes in growth noted are relatively small, they have large impacts on projected inventories, as shown in the following tabulation.

Changes from base level growing stock inventories

	2010	2040
	percent	
Softwoods	3.8	14.9
Hardwoods	2.9	15.3

Just as in the tree planting scenarios described, rising inventories lead to increased harvest and lower stumpage and product prices. Given the regional differences in growth changes, there also is a rebalancing of harvest among regions, between softwood and hardwood fiber types, and between forest industry and other private ownerships. As softwood inventories increase and softwood prices fall, pulpwood demand shifts from hardwoods to softwoods (relative to the mix in the base case). Lower softwood prices also act to increase softwood sawtimber processing capacity and the demand for softwood sawtimber. Higher softwood sawtimber processing, in turn, increases the amount of residues available for pulp. The net effect in the fiber products sector is a modest increase in U.S. consumption of softwood pulpwood and a small decline in hardwood use. In sawtimber, U.S. softwood harvest rises by about 8% by 2040, while hardwood harvest is essentially unchanged.

Lower softwood lumber prices reduce the price advantages of Canadian producers, imports fall, and domestic harvest replaces Canadian harvest. Prices for the base projection (table 36) stabilize after 2015, while prices in this alternative decline after 2015.

WOOD ENERGY

This scenario examines the impacts of a U.S. energy policy that places increased emphasis on the use of wood and other biofuels in meeting national energy demands. The policy includes increases in fuelwood consumption and in the proportion of fuelwood that comes from the growing stock portion of timber inventories. This scenario is derived from the National Energy Strategy (NES) developed by the Department of Energy.[25] Projections of wood used for energy and the percentage coming from non-growing stock sources are shown in table 39. The Forest Service estimates wood energy use in 1986 of 0.78 quads.[26] The NES estimates wood energy use as 1.29 quads in 1989. No attempt was made to resolve these differences, and the Forest Service numbers were used as the starting point.

Differences in the percentage of fuelwood coming from non-growing stock result, as higher rates of fuelwood use come increasingly from whole-tree harvest operations. The fraction of harvest coming from non-growing stock sources varies substantially by type of product, being relatively low for solidwood products such as lumber and generally highest for fuelwood. Given the large volumes of fuelwood that may be consumed in the future, the so-called "non-growing stock fraction" for fuelwood is particularly important. For example, in the base run, 76.2% of the hardwood fuelwood harvest of some 2.9 billion cubic feet is expected to come from nongrowing stock sources by 2000. Thus only about 8% of the base projection of U.S. hardwood growing stock harvest in 2000 goes to fuelwood. If all of the hardwood fuelwood harvest came from growing stock, the fraction would jump to 27%.

Of the approximately 737 million acres of forest land in the United States, 47 million acres are reserved from any harvest, and 200 million acres are low productivity forest land.[27] The remaining 490 million acres classed as "timberland" support most of the harvest for pulpwood and sawtimber products. Much of the fuelwood harvest, however, comes from urban forest land, low-productivity forest land, or from residues left after logging. As a consequence, there is little harvest of fuelwood on timberland acres in many regions. For example, it is estimated that only 27% of all fuelwood in 1991 came from timberlands. Generally softwoods comprised a slightly higher proportion of the fuelwood removed from timberlands, but there is great variation in the species mix across regions. The effect of these considerations is to further reduce the draw of fuelwood harvest on timberland growing stock.

This scenario was conducted by essentially "forcing" our models to harvest the fuelwood volumes shown in table 39. In effect, fuelwood use had precedence over any other demands on the timber base. Thus, where fuelwood harvests in the scenario exceed those in the base, there is less timber available for other products, forcing stumpage and product prices up and sawtimber and pulpwood harvests down. The net effect by the year 2040 is to increase U.S. harvests for both softwood and hardwood by 9% and 61%, respectively. In the softwood sector, softwood lumber and plywood consumption are somewhat lower, as is pulpwood harvest. Hardwood lumber output is also slightly reduced. Product prices show little change, but sawtimber stumpage prices

[25] *25.U.S. Department of Energy. 1991. National energy strategy, technical annex 2: Integrated analysis supporting the National energy: methodology, assumptions and results. DOE/S-0086P. 171 p. On file with: USDA Forest Service, Forest Products Lab, Madison, WI 53708-2398.*

[26] *26.A quad is 10 to the 15th BTU (British thermal units).*

Table 39.—Fuelwood consumption and non-growing stock fractions for the base case and biofuel scenarios.

Fuel & year	Base		Biofuel scenario	
	Softwood	Hardwood	Softwood	Hardwood
	million cubic feet			
Biomass fuelwood consumption:				
1986	520	2,580	520	2,580
2000	670	2,900	1,030	3,940
2010	880	3,070	1,650	6,020
2020	880	3,240	2,160	7,200
2030	840	3,550	3,040	9,890
2040	910	3,900	3,200	10,070
	percent			
Fuelwood from non-growing stock sources:				
1986	61.5	76.7	61.5	76.7
2000	58.2	76.2	73.4	73.4
2010	60.2	76.9	81.8	81.8
2020	61.3	77.5	70.2	70.2
2030	64.3	79.7	60.6	60.6
2040	67.0	80.8	67.0	67.0

[27] *Lands capable of growing less than 20 cubic feet of timber per year are classed as forest land but not timberland.*

are higher in some regions for softwoods (up 4% in the South by 2040) and sharply higher for hardwoods (+9% in the North and +20% in the South by 2040). Private softwood and hardwood inventories in 2040 are also lower, reflecting higher total harvests (–8% for softwoods and –18% for hardwoods).

CHANGES IN NATIONAL FOREST HARVEST

Over the past 5 years, harvests from National Forest lands have decreased by more than 50%. The National Forest harvest projection in the base assumes the adoption of Forest plans; implementation of the President's plan for harvests on western forests, including habitat for the northern spotted owl, protection of the red cockaded woodpecker (*Picoides borealis*) in the South; elimination of below-cost timber sales; and elimination of harvesting in existing roadless areas. These considerations yield harvests that are about half their levels in the 1980s.

In this section, we examine a scenario in which National Forest harvest levels return to the levels of the late 1980s. This is the same projection used as the base case for the 1989 RPA Timber Assessment. It represents a continuation of harvest levels observed in the late 1980s, with increases after 2000 coming from planned harvests in the Rocky Mountains. Total National Forest harvest for the base and this scenario are as follows:

Year	Scenario: continued harvest at 1980s levels[a]	Current (base) National Forest harvest
	billion cubic feet per year	
1986	2.07	2.07
2000	2.00	1.12
2010	2.17	1.15
2020	2.23	1.19
2030	2.28	1.22
2040	2.32	1.25

[a]*These levels are equivalent to base National Forest harvest assumptions in the 1989 Assessment.*

Changes in National Forest harvest in this scenario are concentrated in the West. They are partly offset by changes in harvests on other ownerships in the West and in other regions. Increases in National Forest harvest lead to lower stumpage prices that, in turn, decrease timber harvests from private timberlands. Lower stumpage prices lead to lower product prices, reducing product output in regions with little national forest timberland. Thus, in the South stumpage prices are 5.7% lower by 2040, and sawtimber harvest is reduced by about 2%. On the Pacific Coast, where National Forest harvest plays a larger role, stumpage prices are reduced by 15.6% in 2040, and sawtimber harvest rises by about 8% (despite some reduction in private cut). These lower stumpage prices result in increased lumber consumption (2.2% in 2040) and lower product prices (-1.3% in 2040 in the case of softwood lumber). There are no significant impacts in hardwood markets, illustrating the small role of National Forests in the hardwood sector.

COMBINED ENVIRONMENTAL AND ENERGY POLICIES

The previous scenarios involved variation in only one element (or related set of elements as in the alternative macroeconomic outlook) in a projection. The results are instructive in understanding the isolated impacts of specific policies or developments. From a practical standpoint, however, it is more likely that several changes in policies and background will occur together (or close in time). Further, in the context of a dynamic resource such as forests, the impacts of a set of changes may not be the simple sum of the impacts of the changes taken in isolation.

In this alternative, we look at a combination of three policies aimed at environmental and energy issues: (1) higher rates of wastepaper recycling to reduce pressure on landfill capacity and encourage higher timber inventories as carbon sinks; (2) increased use of wood for energy to replace fossil fuels; and (3) tree planting subsidized by the $110 million funding per year for 10 years to expand timber supply and increase sequestration of atmospheric carbon.

As shown in table 36, the increased wood demands associated with the biofuels policy dominate the results in this scenario, swamping the wood-

saving effects of increased recycling and the inventory augmentation of higher planting rates. By 2040, increments in total U.S. harvest of softwoods and hardwoods, at 9% and 60%, respectively, are little different from the biofuels alternative. During the initial portion of the projection, private softwood inventories rise above the base, reflecting the additional planting of 5.1 million acres to softwoods in the Southcentral region. By 2040, however, both softwood and hardwood inventories have been reduced below the base as cut continues to rise. Solidwood and pulpwood consumption are lower and stumpage prices are higher, because fuelwood use is assumed to take precedence in harvests.

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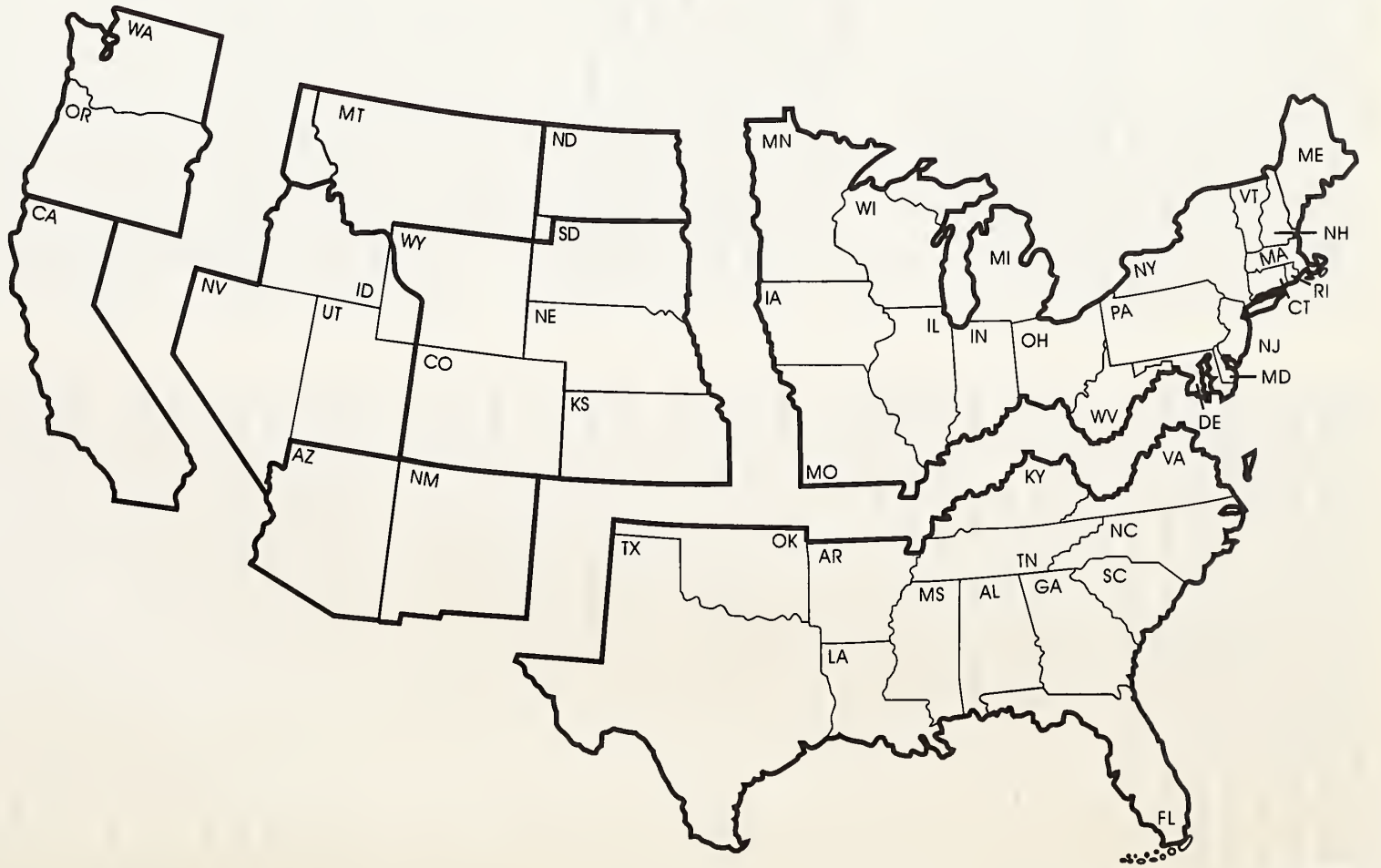

Abstract

Haynes, Richard W.; Adams, Darius M.; Mills, John R. 1995. The 1993 RPA timber assessment update. General Technical Report RM-259. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 66 p.

This update reports changes in the Nation's timber resource since the 1989 RPA timber assessment. The timber resource situation is analyzed to provide projections for future cost and availability of timber products to meet demands. Prospective trends in demands for and supplies of timber, and the factors that affect these trends are examined. These include changes in the land and timber resource base. Changing resource conditions that may lead to policy changes or that may represent opportunities for private or public investment also are identified. Market and resource trends are interpreted to provide an improved basis for managing the resource base.

Keywords: RPA, assessment, timber, projections, supply and demand, management alternatives